ROAD

Roadway Object & Attribute Data

DRAFT

STANDARDS & PROCEDURES

FOR LRS/GPS FIELD DATA COLLECTION

Version 1

Washington State Department of Transportation
Transportation Data Office

1. INTRODUCTION

THE ROAD PROJECT

The following standards and procedures describe the equipment and processes through which roadway geometric and safety related data will be collected, validated and stored for the Roadway Object and Attribute Data (ROAD) project. This effort will focus on the collection of roadway features currently found in the TRansportation Information and Planning Support system (TRIPS), as well as specific roadside objects identified by the Federal Highway Administration and the University of North Carolina Highway Safety Research Center. We have also solicited input from Washington State Department of Transportation (WSDOT) Maintenance, Risk Management, Engineering and Design Teams.

In addition, the data that is collected will be used to determine the feasibility of using GPS / GIS to establish a more accurate way of collecting milepost values for our existing Linear Referencing System as well as a reliable and comprehensive Geospatial Referencing System. Through cost/benefit and comparative analysis techniques, we will be able to evaluate which alternatives will ultimately provide us with a direction for future data collection programs.

LINEAR REFERENCING SYSTEM / GLOBAL POSITIONING SYSTEM

Linear Referencing System

Currently, all roadway data is collected using WSDOT's Linear Referencing System (LRS) - State Route (SR) ID Number and State Route Milepost (SRMP).

For further detail on WSDOT's Linear Referencing System, see Appendix A.

Historically, roadway data was collected to the hundredth of a mile using a Distance Measuring Instrument (DMI), and entered into TRIPS. The ROAD project will continue to collect data using the LRS, but will collect it to the thousandth of a mile, establishing a new Accumulated Route Mileage (ARM) value for all State Routes surveyed, as well as the features associated with that route. For the purpose of this document, the term "milepost" will refer to an ARM value.

Global Positioning System

The Global Positioning System (GPS) is an effective tool for positioning and navigation and is widely used by both the private and public sector. As a developing technology, there are risks involved with using GPS. These risks are best understood and avoided by ensuring appropriate levels, training, education and validation by everyone involved with this project.

With regard to GPS, this document particularly targets surveys where the required accuracies to be achieved are mapping level (sub-meter to five meters). It will also provide a methodology that can be utilized within the Department for GPS / LRS surveys. For further information on GPS, see Appendix B.

All GPS data collected for this project will use the standards set forth by the Federal Geographic Data Committee, in the *Draft Geospatial Positioning Accuracy Standards, December 1996* as a foundation.

2. PROJECT PERSONNEL

The ROAD Project will utilize one or more person dedicated to one or more of the following tasks:

PROJECT SUPERVISOR

The Project Supervisor (PS) is responsible for the quality and reliability of all phases of The ROAD Project. The PS is responsible for ensuring that all personnel have adequate training and supervision; and that all data is correctly collected, processed, interpreted, presented, and archived. The PS is responsible for project planning, implementation, and completion.

FIELD CREW CHIEF

The Field Crew Chief (CC) is responsible for computer operations, equipment care and maintenance, downloading and archiving of field data, and supervising Field Operators. The CC should have the qualifications of a Field Operator, as well as training in the care and maintenance of the equipment, downloading and backup procedures, and training in the use of computers and database software.

FIELD OPERATOR

A Field Operator (FO) will perform the actual data collection. The FO must be familiar with operation and troubleshooting of the GPS receiver, with basic GPS concepts (especially sources of error specific to GPS), with the methods of data capture to be used, and with knowledge of the highway system sufficient to interpret features in the field.

DATA TECHNICIAN

The Data Technician (DT) is responsible for the processing of all data to meet the project accuracy standards, and the archiving of the data as necessary. The DT will be familiar with the Linear Referencing System (LRS), GPS concepts, DGPS data collection methodologies with respect to the ROAD Project, post-processing of GPS data, specific processing software, GPS quality analysis and verification procedures, and basic concepts of geodetic datum and coordinate systems. The DT will also be familiar with GPS data and mapping concepts, including:

- Integrating GPS data with other data sources.
- Interpreting GPS data and field information to develop map or coordinate products.
- File translations between GPS and mapping software, and the mapping and/or GIS software used.

SAFETY TECHNICIAN

The Safety Technician (ST) will be responsible for field safety operations, including: flagging, spotting, signing, operation of shadow vehicle, and the general safety of the crew members.

3. EQUIPMENT

DISTANCE MEASURING INSTRUMENT (DMI)

The DMI utilized for the ROAD project is the JAMAR RAC-200. It is configured to communicate at 9600 baud. The JAMAR DMI has an RS-232 serial port and uses it's own language for communication. The DMI will be used to collect ARM value's for all features.

GPS RECEIVER & ANTENNAE

Initially, the GPS receiver we will be using in the ROAD van (data collection vehicle) to collect XYZ on the mainline in 50 ft. intervals, will be one of the Trimble Pro XR receivers discussed below. It has an internal US Coast Guard CORS receiver which allows it to receive data from one of several CORS sites located along the coast of Washington and Oregon. This is a real-time GPS/GIS data collection and mapping, high-performance GPS receiver and antenna, with a MSK beacon differential correction receiver (XR) that will collect submeter GPS data. The Pro XR will accept a standard correction signal called Radio Technical Commission for Maritime Services (RTCM). This helps the GPS attain better accuracy, real time. Differentially corrected sources are provided through several

CORS base stations along the West coast of Washington, eliminating the need to establish a reference station. We will also be using the Pathfinder Pro XR receivers with TDC 2 Data Loggers for field data collection. In addition to collecting XYZ to create a GPS line feature for the State Route mainline, the ROAD crew will be collecting coordinate values for all roadside features.

Since there are some areas in Eastern Washington where the CORS stations do not have adequate coverage, we will also be using a second system called Omnistar. The Omnistar provides differentially corrected coordinate values via satellite. The ROAD crew will be able to transfer the signal they are receiving from the CORS base station, to the Omnistar satellite when they leave the CORS coverage area. At that point it will start accepting the corrected signal from the Omnistar. The Omnistar is satellite based and works throughout the state, however, it has only one satellite which is located 30 degrees above the horizon to the South. The reason for utilizing 2 different differential correction sources is so that we can insure adequate coverage throughout the state.

TRIMBLE TFC1 PORTABLE COMPUTER

The TFC1 is a portable IBM compatible computer that uses the Microsoft MS-DOS operating system and the Microsoft Windows Graphical User Interface. It will be used as a portable system that will allow GPS data collection (in conjunction w/Pro XR Receiver) and GIS mapping for field validation.

HARDWARE / SOFTWARE

An onboard Pentium 200 will be used for data collection and storage while in the field. The database and front-end data entry screens will be constructed using Powerbuilder and SQL Anywhere (see section on Database Construction). The ROAD crew will be utilizing Pathfinder Office and Aspen Software which will also reside on the P200. Once the crew returns to the office at the end of the work week, the data will be downloaded into a SQL database warehouse that will reside on a server(s) at WSDOT’s Management Information Systems (MIS) office. Further validation of the data can be performed once the data is downloaded into the warehouse. It is anticipated that users within the TDO will be able to query the data prior to the data being merged with existing TRIPS data.

LASER RANGEFINDER

Laser rangefinders allow a person to stand in one location and collect the range measurement of a slope distance with roll, inclination and magnetic bearing by aligning the Heads Up Display (HUD) sighting reticle on the target and squeezing the trigger. Laser Atlanta Optics manufactures the Advantage Laser Rangefinder which is the unit that will be utilized by the ROAD crew. It is a Class 1 Laser Product. The Advantage provides reflectorless operation, is GPS data logger ready and has an integrated digital compass/inclinometer. It has a range from 5 to 1,500 feet (w/o reflector) and has an acquisition time of 0.3 seconds. The rangefinder is also equipped with a 10X monocular sight to insure accurate targeting.

The Advantage Laser Rangefinder utilizes one of the most advanced compass sensors available today so there are some very important steps to take in order to achieve the accuracy the Laser is capable of. They are:

- Make sure you read the manual and understand it.
- Calibration of the compass.
- Damping settings.
- Bearing Alarm must be activated.

Other issues to look at are:

- Range and Serial menu settings.
- Memory in the System Menu (very important).

DIGITAL CAMERA

A Minolta RD-175 3-CCD High Resolution Digital Camera will be utilized to capture images for research and for the database. The RD-175 uses three CCD imaging arrays and a unique signal processing technique to provide high resolution of 1.75 million pixels (1528x1146). This achieved by diagonally shifting each CCD pixel to fill any gaps. Up to 114 images can be stored on the 130MB drive. The images can be downloaded and deleted from the camera's drive by tethering the camera to the onboard computer by way of a built-in SCSI-2 interface. Once downloaded, the images can be linked to the appropriate records or brought back to the office for research purposes.

DIGITAL ELECTRONIC LEVEL

The ROAD crew will be using the "SmartLevel", a digital electronic level made by the Macklanburg-Duncan Co., to estimate all side-slopes along highway corridor. The SmartLevel reads all angles trough 360°, displaying these measurements in four different modes: angle, slope, pitch and simulated bubble.

HANDHELD FM RADIO

Communications between the Field Operator(s) and the Crew Chief will be accomplished by using handheld FM radios. We will be using the RITRON

PATRIOT RTX-050-H programmable, 11 channel, 2-way radio that operates in a professional FM communications band.

ROLLATAPE (WHEEL)

The Rollatape, or “Wheel” as it is often called, will be used primarily for taking a quick measurement, e.g., measuring a lane width, when it can be accomplished safely and more efficiently than another piece of equipment.

> *In many instances, there will be number of tools that can be used for collecting data on the various features. It will be necessary in these instances for the crew chief to decide which tool should be used to accomplish the task in the safest and most efficient manner.*

4. SAFETY

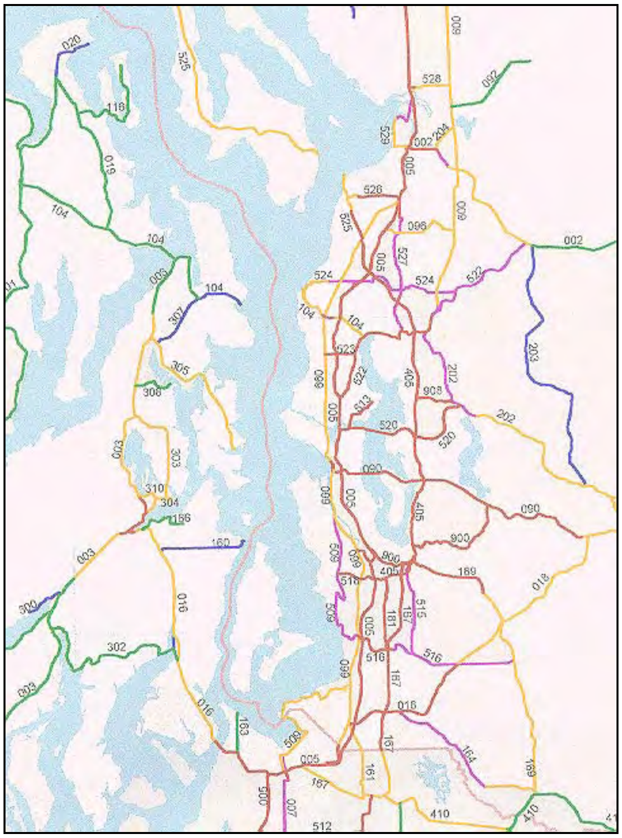
WORKZONE SAFETY

Safety of the field crews and the traveling public are paramount. All procedures, equipment purchases and vehicle modifications were developed and tested with safety being the number one concern.

Safety guidelines and procedures for this data collection effort were prepared in accordance with the *Workzone Traffic Control Guidelines M 54-44 - WSDOT July 1994* and are described in the following text.

TRAFFIC SAFETY ZONES

This section covers the Traffic Safety Zones and General Operating Procedures for field crews.



TRAFFIC SAFETY ZONE MAP

All State Routes have been assigned a safety classification. These classifications were determined by the Transportation Data Office in cooperation with the Regions.

The Traffic Safety Zones are described below, each color having specific restrictions and/or procedures that must followed.

Traffic Safety Zone maps (similar to the example shown at left), the zone definitions and the General Operating Procedures are available from the TDO upon request.

ZONE DEFINITIONS

Red Zone:
No personnel can work in the lanes of travel without traffic control.

Green Zone:
An individual may enter the lanes of travel without traffic control.

Yellow Zone:
One "spotter" or traffic control person must be present prior to working in the lanes of travel.

Blue Zone:
An individual may enter the lanes of travel without traffic control during off peak hours.

Purple Zone:
One "spotter" or traffic control person must be present prior to working in the lanes of travel during off peak hours.

FIELD OPERATIONS

General Operating Procedures

The following General Operating Procedures apply to all data gathering activities:

1. These GENERAL OPERATING PROCEDURES shall be posted on all crew bulletin boards. Data Collectors shall read it and continuously follow it. Before beginning newly planned activities, safe operation procedures and safe equipment usage, procedures shall be reviewed.

2. Each Data Collector shall comply with the safe practice rules of this code and any other safety laws, rules, policies, or procedures applicable to the work being done.

3. Each Data Collector shall be provided with the latest personal protective equipment and shall be required to wear it whenever he/she is exposed to traffic, as required by department policy, or safety requirements.

4. It is each Data Collectors responsibility to work in a safe manner and to immediately report unsafe conditions or procedures to their supervisor. No Data Collector shall be required to work in an area they feel is unsafe. These areas must be reported and discussed with their supervisor.

5. Vehicles must be parked completely off the traveled way. The flashing amber strobe lights shall be operating when working on the traveled way. Do not unnecessarily stand or work between the vehicle and traffic or at the rear of the vehicle. Whenever it is necessary to work near the vehicle, attempt to work at the side away from traffic. If possible, find a position where you can stand facing oncoming traffic. When possible, park so that backing is not necessary.

6. Plan escape routes ***before*** starting work outside the vehicle.

7. Data Collectors shall face the direction of traffic for the lane they are working in and constantly be watching for traffic.

8. Data Collectors shall work from inside the vehicle or behind the guardrail or barrier where possible. While working from outside the vehicle, hard hats, and safety vests must be worn. The vehicle should be parked in the same direction as traffic, in as safe a location as possible. The vehicle should be properly ventilated.

9. Data Collectors may work on the traveled way if traffic is light and sight distance is good. This means the Data Collector can walk from the shoulder to the site on the traveled way, do the job in a deliberate manner and walk back to the shoulder without interfering with traffic in any way.

Do not cross the traveled way unless there is enough time to walk across it. If you have to run, there is inadequate time to cross the traveled way safely.

10. The sight distance for Data Collectors will be a minimum of 500 feet. Consideration will be given to highway geometric and average vehicle speeds in order to determine whether the sight distance should be more or less. If the work cannot be safely accomplished in this manner, a spotter with an audible warning device shall be required to assist.

11. The exclusive duty of the spotter is to continually watch for approaching traffic and to warn and/or remove the worker from the traveled way whenever trouble is suspected. The spotter will be posted in an area best suited for the earliest detection of trouble and the reduction of exposure to the worker. The spotter shall do nothing to control or influence traffic.

12. All workers will be off the traveled way while traffic is passing.

13. Working at night shall only occur when daytime conditions prohibit safe working conditions. The night time work shall be in conjunction with maintenance lane closures and/or WSP assistance.

14. The Transportation Data Office in cooperation with the Regions are to identify sections of State Routes that: are safe for the placement of traffic counters by one person; require the use of a second person as a spotter; require approved traffic control procedures (i.e. lane closures by maintenance forces, assistance of WSP Troopers by conducting rolling slow downs and/or enforcing excessive speed and drinking driver laws); are unsafe for the manual placement of traffic counters. Generally these sections have the following characteristics:

    A. Safe Sections For One Person

        - Ideally Low Speed/Low Volume (i.e. 35 mph or less/less than 5000 ADT or 1,000 vehicles per hour)
        - Rural Highway Sections (Low Volumes)

    B. Sections For Spotters, Maintenance Lane Closures, and WSP Assistance

        - Moderate to High Speeds and/or Moderate Volumes

    C. Unsafe Sections

        - High Speed and/or High Volumes (e.g. Urban Freeways and Highways)

15. If traffic conditions are such that the work cannot be done in a safe manner, consideration shall be given to:

    A. Roadway Inventory Data

    - Using Contract data as the best available data rather than field measurements.
    - Using Aerial Photographs for data.

16. All tools and equipment shall be inspected regularly, by the data collector, to insure they are in good operating condition. Report any deficiencies to the supervisor. Defective tools shall be removed from service until repaired or replaced.

17. When power tools are used, guards shall be in place and adjusted per manufactures instructions. Check the personal protective equipment requirements for the particular power tool being used.

18. Supervisors shall ensure that only qualified persons operate power-actuated tools and carry a valid operator’s cards for the tools, if required.

5. DATA COLLECTION

HIGHWAYS TO BE INVENTORIED

The initial highways to be inventoried as part of the ROAD Project are classified as National Highway System (NHS) Principal Arterial (PA). Ultimately, we anticipate inventorying all eight thousand five hundred plus miles of highway in Washington.

The initial phase of the ROAD Project (approximately six months), will be to refine the data collection procedure, prepare cost per mile estimates for various types of highway (two and four lane rural and urban, limited access, etc.), and do some initial testing of the database query system. The cost per mile estimates will give us an indication of the cost to complete the entire statewide inventory.

WIDTH OF ZONE TO BE INVENTORIED

A decision was made to **not** inventory “clearzones” due to the numerous factors involved in determining a “clearzone”. We feel that the “clearzones” can be calculated using the data collected, the standard formulas, plus AADT, speed limit, etc.

The actual width inventoried will depend a great deal on the conditions in the field. This would include: urban or rural location, degree of slope, distance to “boundary object” (objects such as continuous tree group, water, rock wall, building, etc., through which a vehicle could not pass) and other factors. However, we have established some guidelines for minimum distance inventoried. Those guidelines are:

> Rural or Urban Areas, Speed Limit 45MPH or greater - 150 feet **minimum** or “boundary object”.
>
> Rural or Urban Areas, Speed Limit less than 45MPH - 120 feet **minimum** or “boundary object”.

If there is any doubt about inventorying an object beyond the minimum distance, the crew chief will make the decision. His first choice (within reason) will **always** be to inventory the object(s), safety permitting. Our crew is experienced and will use their judgment to determine inventory objects. They will not inventory an object at the bottom of a fifteen hundred foot slope, just because a vehicle could reach it.

COLLECTION & STORAGE

Data for the ROAD project will be collected by way of computer & equipment interfaces, manual data entry with user friendly data entry screens, and import / export processes that will be developed in Powerbuilder. ROAD data will be stored in a SQL database.

This section covers the various objects and object attributes, their definitions, and the collection procedures that will be utilized. In most cases, the objects that will be collected are listed in the order of collection. There will be instances where conditions in the field will prevent following the exact order outlined herein. However, mainline GPS and mainline control will be the first items collected for all State Highway surveys.

The data elements listed herein have been arranged into logical groups allowing the crew to concentrate on a smaller portion of the data elements to be collected while they make a pass. The intent is to facilitate a smooth flow for field procedures, to eliminate the potential of “missed” data elements due to an overwhelming amount of data that must be collected, and to aid in the validation of the data in layers through GIS software. These groups have been classified as “Runs” and have been given names that make it easier for the field crew to recall the elements within a certain group, e.g., Control Run, Geometrics Run, etc.

PREPATORY WORK

This type of data collection will require a certain amount of prepatory work. By locating and marking these features in advance, it will facilitate the collection of information more accurately and efficiently.

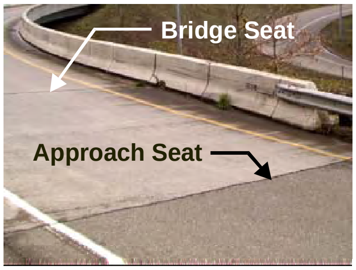
Marking Features

In advance of the data collection phase, the crew will prep the site by locating and marking all bridge seats within the project limits.

Culverts, GPS monuments and intersection points should also be located and marked at this time.

LOCATING BRIDGE SEATS

Bridge Seats are the transverse joints located at both ends of the bridge where the girders (or deck) tie into the abutment. They are relatively easy to locate, however, in some cases the bridges have been overlayed making the task more difficult. The following examples will help to identify Bridge Seats



In most cases, the first seam will be the beginning of the approach slab. The next seam (approximately 20 ft. from the beginning of the approach slab) will be the Bridge Seat (joint between the approach slab and the bridge deck).

Once located, the Bridge Seat is marked (with bright orange paint) to make it easier to locate while collecting control run data on the fly. If the Crew Chief is unable to safely locate the Bridge Seats, it may be necessary to skip the bridge and not use it as control.

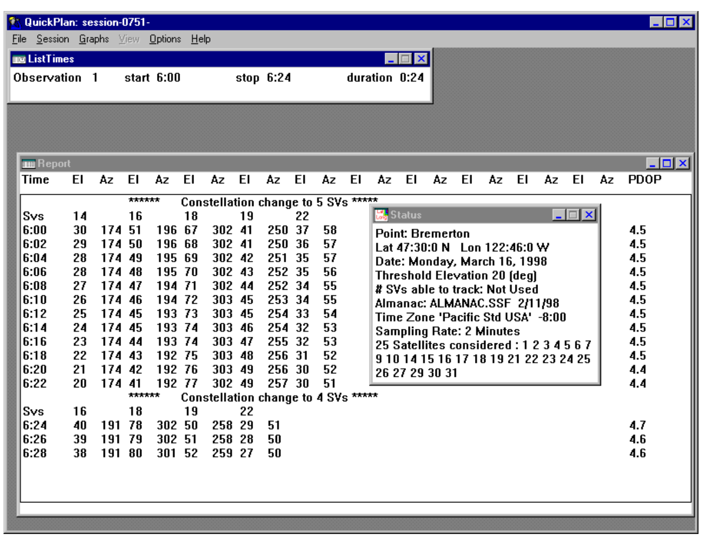
MAINLINE GPS RUN

At some point before and/or during the prepatory phase, the crew will establish a mainline GPS line feature that will be used to create a GIS theme. Coordinate values will be collected on the fly, in both the increasing and decreasing milepost directions. In addition, a “quick mark” (a point manually inserted in a line feature) will be added at all major intersections. This will provide a way to tie the line feature to a physical point on the ground. The line feature will be run in the outside travel lane for the entire route. The vehicle will travel at approximately 30 MPH in order to collect coordinate values at 35 to 40 foot intervals.

The GPS receiver must be placed in the “pause” mode at any stopping point along the way (e.g., signalized intersection) in order to eliminate the distances between the points being collected while in the stopped position. The vehicle should not deviate from the lane of travel and must not pull off to the side of the road unless the receiver is “paused” at a known point. Once the crew is ready to continue the survey, the receiver must “resume” collection of coordinate values from the point at which the survey was “paused”.

Individual points (every 6 to 12 miles) will also be established wherever a previously established GPS monument is not within close proximity to the edge of pavement (EOP). These existing and newly established points, along with the line features, will be plotted using ArcView software. All other features will be plotted in relation to the Mainline GPS theme for validation purposes (see section on Validation). The coordinate values for the Mainline GPS run will not be a part of the database, but will be made available to WSDOT’s Geographic Services.

SATELLITE POSITION & BASE STATION CHECK

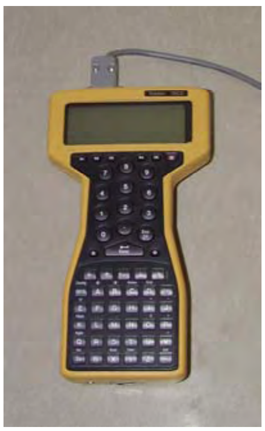


Prior to performing a survey, we will be checking satellite availability. This is a relatively easy process using quick plan in Pathfinder Office. Each time the data collection equipment is used, an almanac of the satellite information is gathered and stored in the data logger automatically.

Once the almanac is transferred to the Pathfinder Office software, simply state when and where you want quickplan to find the optimum time frame to collect data with enough satellite visibility to get good results.

GPS / LRS / DATABASE LINK

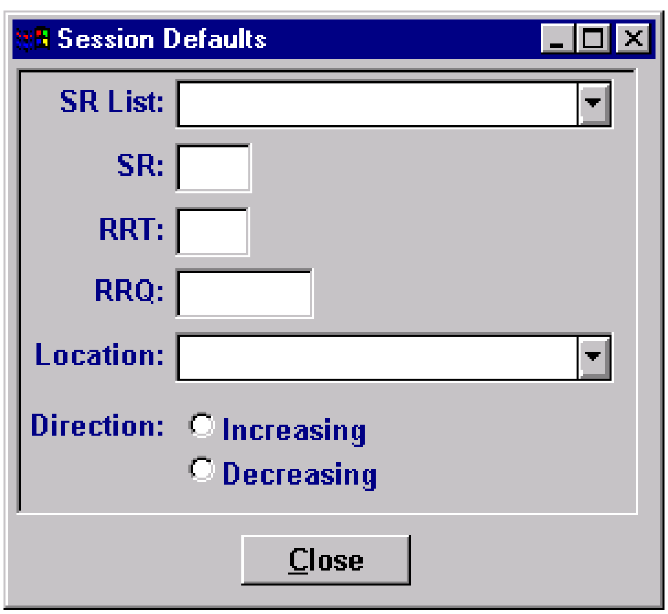
The links between GPS data, LRS data and the ROAD Database will be accomplished by utilizing a computer generated number for each data element collected. This number, called an "Item ID", will be embedded into each record that requires an XYZ value.



Item ID Number

The Field Operator will receive the Item ID number from the Crew Chief by way of portable radio communications. The number will be input into the GPS data logger as an attribute by using the numeric key pad. Since the Item ID is linked to the XYZ value as an attribute, and is also embedded in the record, the two can be merged into the appropriate record at a later date. The merge will take place as a part of the office procedures and will be done after the GPS data has gone through a validation process (see section on Validation).

DEFAULT SCREEN



Default Screen

The Default Screen must be setup prior to any data being collected for the ROAD database (not necessary for the Mainline GPS Run). The defaults can be changed at any time, however, all data collected from that point forward will reflect the changes.

MAIN SCREEN

The Main Screen enables the operator to collect new features, interface with the DMI and capture offset distances.

THE CONTROL RUN

For the purpose of the ROAD project, mainline control is defined as the collection of ARM value's on all bridge seats (begin / end bridge) along the mainline of a State Route as accurately as possible within the constraints of equipment, environment and human error. All object and attribute data collected for this project will be tied to the mainline control ARM value's.

Mainline

Definition - The main lanes of travel of a designated State Route, including both increasing and decreasing milepost directions.

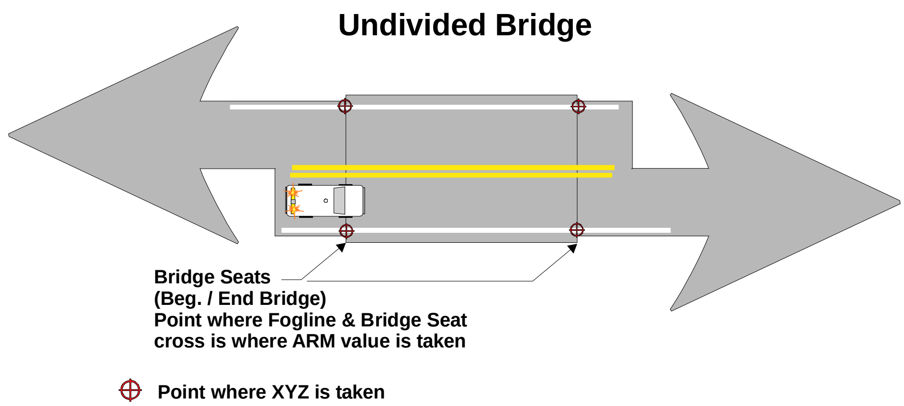
The mainline control of the State Route to be surveyed is the first element that will be collected. All other roadway features will be tied to the mainline control either by milepost or milepost and offset. The control consists of establishing an ARM value for all bridge seats throughout the project.

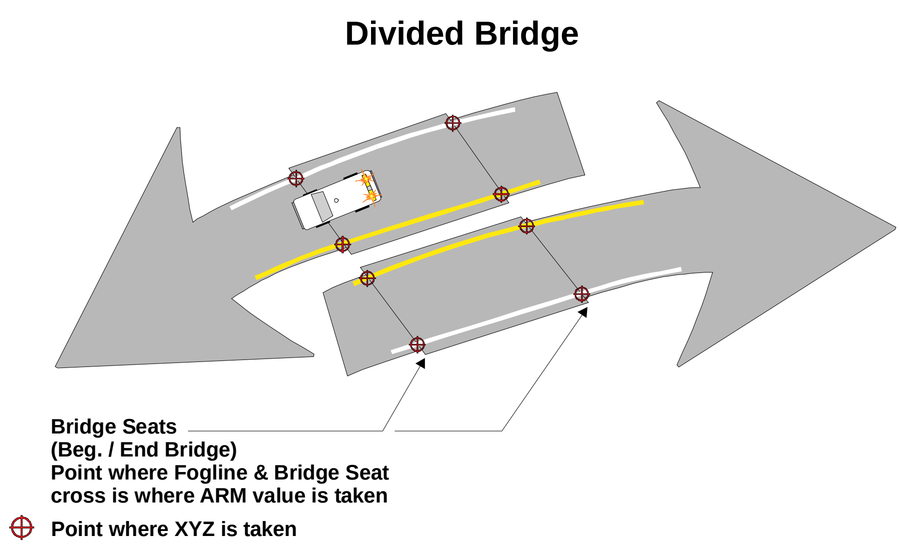
Collection Procedures

The mainline control points will be collected during non-peak hour traffic using a Distance Measuring Instrument (DMI) to collect ARM value's to the thousandth (.001) of a mile. The crew will drive 20 to 40 mile segments of the route without interruption, maintaining a speed that allows the proper collection of the ARM values. The segments will be determined prior to beginning the survey by selecting bridge seats that fall within the segment length limits. These bridge seats, with the exception of the beginning and the end of the route, will act as beginning and ending points for the segments. ARM values for **all bridge seats** within a segment will be collected during a control run. All segments will be driven 3 times (3 passes) and all control points averaged to better insure accuracy.

> *Note: If a situation develops where it is necessary for the crew to shorten a segment because of extenuating circumstances, the crew chief will determine the appropriate termination point (e.g., next available bridge seat). If the segment is not terminated at a bridge seat, the segment pass (3 passes per segment) must be started*

over. Depending on the number of miles driven, the DMI may need to be recalibrated prior to restarting the pass.





During the control run it is important to drive in the middle of the outside lane at all times while maintaining a constant speed. This must be accomplished without stopping or steering the vehicle to the shoulder. If it is necessary to get an accurate DMI reading, slow the vehicle to the necessary speed. Once the MP is collected, resume the appropriate speed.

The crew will begin from a stopped position at the beginning of a route. The "Count Hold" button on the DMI will be released, and the vehicle operator will begin driving the route. The Crew Chief will immediately begin using the State Highway Log to anticipate all bridge seats. Prior to reaching a bridge seat, the

CC will begin a record for the bridge seat by entering the Structure Name and Number. As the crew approaches a bridge seat, the driver will slow down enough to allow the Field Operator (sitting in the passenger seat) to collect the ARM value by sending the DMI reading to the computer with the press of a button. Once sent, the Structure Name and Number, as well as the DMI output will be displayed in the Structures record. Upon completion of a segment, the Crew Chief can close out the record, which will automatically save it. This same procedure will be performed continuously as the crew progresses along the highway.

THE INTERSECTION RUN

For the purpose of the ROAD Project, 4 types of Intersections have been identified.

INTERSECTION TYPES

- Standard Intersections (SI)
- Interchange Intersections (IC)
- Interchange Ramp Intersections (IR)
- Access Intersections (AI)

In addition to the 4 intersection types, we will collect data for Non-Intersection related Traffic Control Devices and Railroad Crossings as a part of the Intersection Run. These features, the methods for identification, location and collection are described below.

STANDARD INTERSECTION (SI)

Definition - The area that encompasses the junction where two or more roads intersect that is not related to an Interchange or limited to access.

INTERSECTION NUMBER

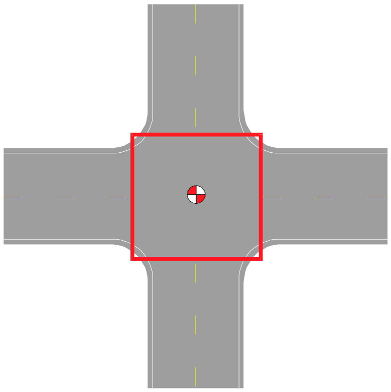
All Intersections within the 4 Intersection Types will receive a 5 character, computer assigned number beginning with - 00001. This number will be unique and will not be repeated. All data relating to an Intersection will key on its unique number.

STANDARD INTERSECTION CONFIGURATIONS

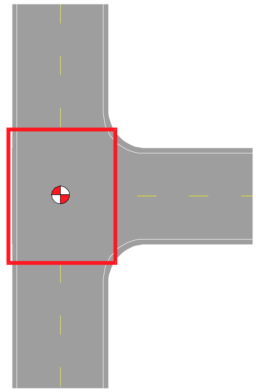
The following is a list of the various Standard Intersection Configurations. They may or may not apply to the 3 other Intersection types.

- Crossing - Right Angle (CR)
- Tee (TE)
- Wye (WY)
- Crossing - Skewed (CS)
- Greater than four leg (GF)
- Offset - 2 T-Intersections (TT)

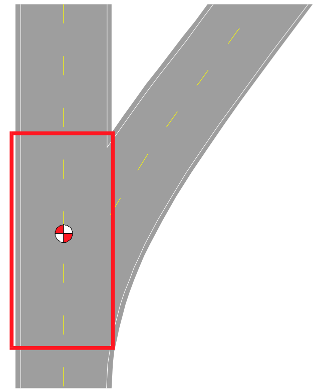
STANDARD INTERSECTION CONFIGURATIONS



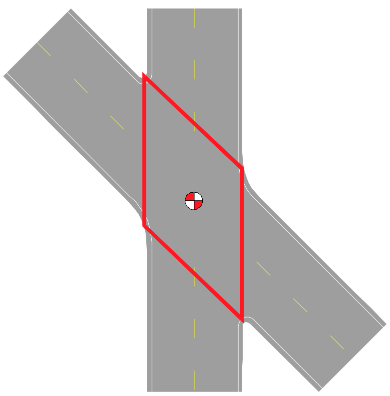
Crossing - Right Angle (CR)



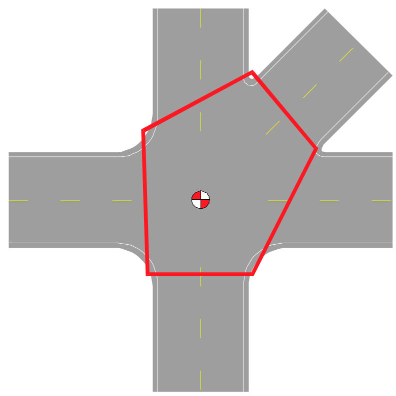
Tee (TE)



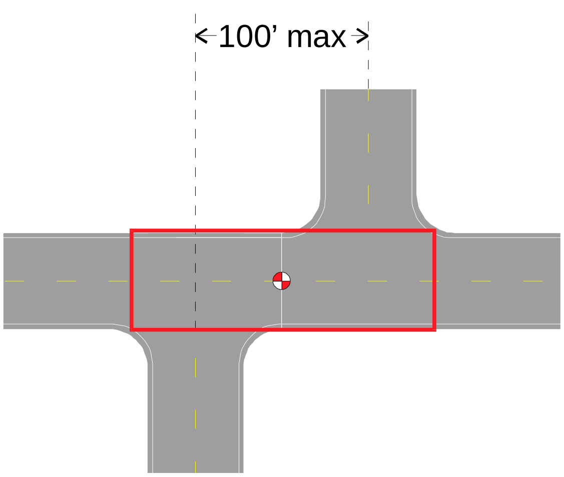
Wye (WY)



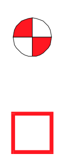
Crossing - Skewed (CS)



Greater Than Four Leg (GF)



Offset - Two T-Intersections (TT)



Intersection Point

Intersection Area

STANDARD INTERSECTION AREA

The Standard Intersection Area (outlined in red) will be located by a single point known as the Standard Intersection Point.

The shape of the Standard Intersection Area will vary depending on the Standard Intersection configuration (shown on previous page)

STANDARD INTERSECTION POINT

The Standard Intersection Point is the point in the center of the Standard Intersection area. This point will be assigned a unique number that will carry with it all the intersection features and their attributes. A single coordinate value will be collected at the Standard Intersection Point. An ARM value for both increasing and decreasing milepost directions will also be collected and associated to the Intersection Point. An intersection point will be collected for each Intersection within each of the 4 Intersection Types. The location of the Intersection Point may vary from type to type, but for each type, location techniques and collection procedures will be described.

MOST COMMON NAME

The most common name of an Standard Intersection will be recorded. For example:

> The Intersection at SR-527 and 128th St. SE is commonly referred to as - **Murphy's Corner**

An alternate name can also be recorded if needed.

INTERSECTION ILLUMINATION

Indicate whether Illumination is present at the Standard Intersection by selecting "Yes" or "No".

GENERAL ENVIRONMENT

Of the General Environmental Types listed below, select the type that best describes the character of the area.

General Environment Types

- Urban
- Rural
- Suburban - Mixed

STANDARD INTERSECTION LEG

Definition - A combination of lanes, including approach and departure, by MP direction, that flow to and from an intersection from a specific compass direction.

Standard Intersection data will be collected by MP direction (inc./dec.), according to the Leg(s) associated with the MP direction. Each Leg will have approach and departure lanes of varying types, e.g., turn, acceleration, general purpose, etc.

The following information will be collected by Leg.

LEG NAME

The most common Leg Name will be recorded. The name will have to be truncated if it exceeds 18 characters. An alternative name can also be recorded.

LEG LANE TYPES

One or more of the following Lane Types will be found at Standard Intersections.

General Purpose (GP)

Also called through lanes, General Purpose Lanes are the main lanes of travel of a State Route.

Auxiliary (AX)

Auxiliary Lanes are less than 1 mile in length and typically extend from an on ramp to the next off ramp, or from intersection to intersection.

Bicycle (BL)

Bicycle Lanes are delineated by a 6” white stripe, signed and/or marked with a Preferential Lane Symbol and/or the standard bicycle symbol and are from 4’ to 10’ wide.

CHANNELIZED / PROTECTED LANES

Turn (TN)

Turn Lanes are those lanes that direct traffic by way of pavement markings and/or delineation into a turning movement.

Turn Lanes will require the following additional information:

Channelization

Types

- Raised Island (RI)
- Painted Island (PI)

Lane Protection

Types

- Protected/Permissive left turn (PP)
- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)

- None (NN)

Acceleration Lane (AL)

Acceleration Lanes are defined as a Lane with enough length to allow a vehicle to reach highway speed prior to merging into a through lane, and are typically utilized following a right turn Lane.

Acceleration Lanes will require the following additional information:

Lane Protection

Types

- Protected/Permissive left turn (PP)
- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)
- None (NN)

ALTERNATE USE LANES

HOV (HV)

High Occupancy Vehicle (HOV) Lanes are signed, and marked with a Preferential Lane Symbol (diamond).

Transit (TR)

Transit Lanes are signed and restricted to Transit only.

Alternate Use Type - Record use hours: From_____ To_____ for Alternate Use approach and departure Lanes.

Collection Procedures

The type of Lane, beginning and ending ARM values, number of Lanes, width and surface type will be collected for all Lane types. At areas other than Intersections, lane data will be collected as a part of the geometrics record (see section on Geometrics Run).

LANE WIDTH

Definition - The width of a lane from center of stripe to center of stripe.

Collection Procedures

Lane widths will be measured from the yellow stripe to fogline (white stripe), from fogline to skip-stripe, or from skip-stripe to skip-stripe. An ARM value will be assigned at each change in width and a new width will be collected.

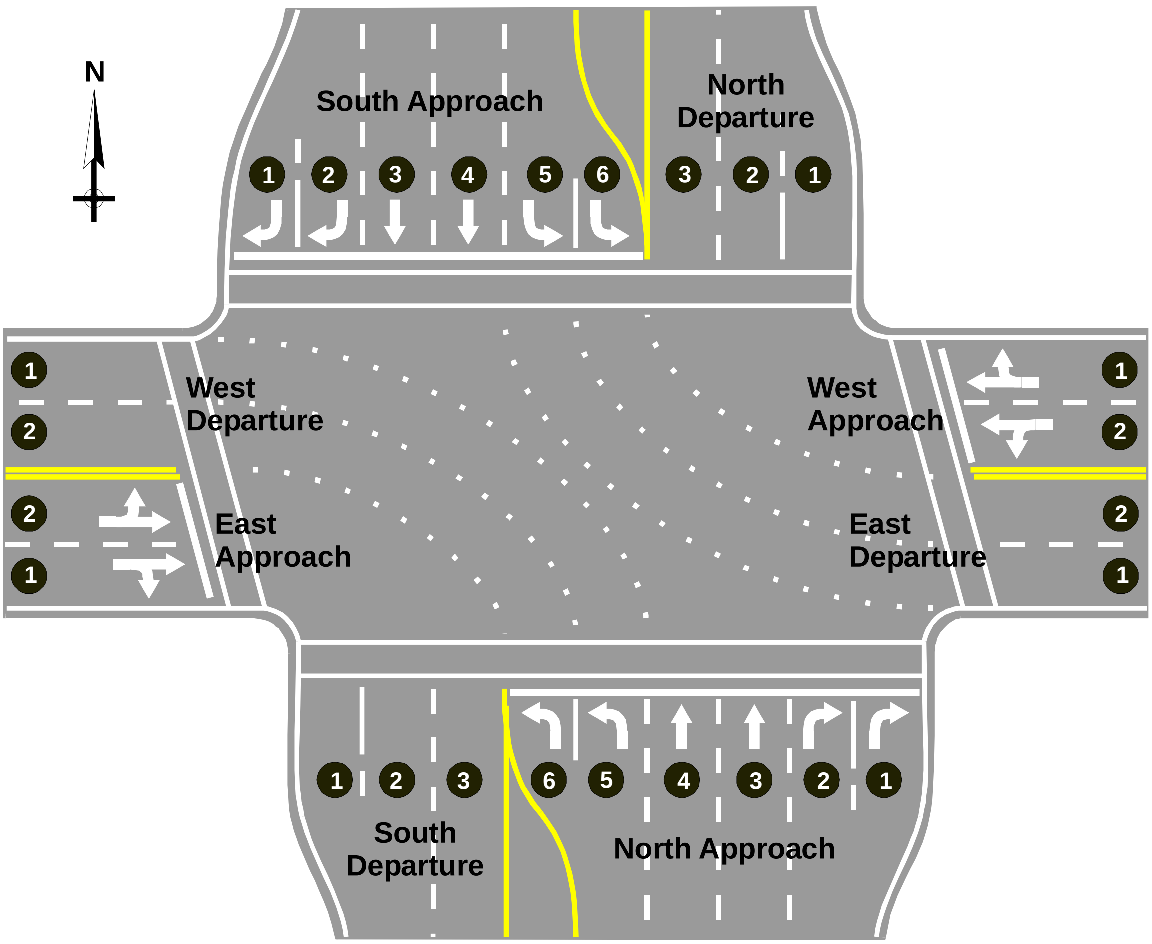
LANE NUMBER

Definition - The number associated with a lane occurring on a State Route Intersection Leg.

Collection Procedures

A Lane Number will be assigned to each Lane beginning with the number 1 which is always assigned to the outside lane. As new Lanes begin, the next consecutive number will be used. As a Lane is terminated, the highest number will be eliminated.

INTERSECTION LANE NUMBER AND LEG ASSIGNMENT



At an intersection, all lanes, including turn pockets, are numbered. Lanes are numbered from right to left, as viewed when facing the direction of travel.

LANE SURFACE

Definition - The top layer of material occurring on the General Purpose travel lanes of a State Route.

Surface Types

- Asphalt (A)
- Bituminous (B)
- Portland Concrete Cement (P)
- Gravel (G)

Collection Procedures

Lane Surfaces will be collected by way of visual assessment. An ARM value will be collected at all changes in surface conditions.

LEG LANE MOVEMENT TYPE

The following Movement Types will be assigned to each Leg Lane:

Movement Types

- Thru (TH)
- Left (LT)
- Right (RT)
- Thru-Left (TL)
- Thru-Right (TR)

LEG COMPASS DIRECTION

The Compass Direction will be collected for each Leg. Eight Compass Directions are available. They are:

- N (1)
- NE (2)
- E (3)
- SE (4)
- S (5)
- SW (6)
- W (7)
- NW (8)

TRAFFIC CONTROL

One of the following Traffic Control Types will be collected for each leg:

- Signalized (SG)
- Stop Sign (SS)
- School Zone (SZ)
- Red Flashing (RF)
- Amber Flashing (AF)

- Yield Sign (YS)
- Railroad Signal (RS)
- Pedestrian Control (PC)
- Fire Signal (FS)
- Officer/Flagger (OF)
- None (NN)

RAILROAD CROSSING WITHIN 200 FEET OF INTERSECTION

Select indicator if a Railroad Crossing exists on the cross street within 200 ft. of intersection. Railroads that cross a state highway will be collected in more detail (described later in this section).

SURROUNDING ENVIRONMENT

The Surrounding Environment will also be determined according milepost direction for each Leg.

- Central business district (CB)
- Strip commercial area (SC)
- Shopping center (SH)
- Industrial area (IA)
- Residential area (RA)
- School (SH)
- School crossing (SX)
- Agricultural (AG)
- Emergency service (ES)
- Park (PK)
- Campground (CG)
- Recreational, e.g., golf course (RC)
- Elderly (EL)
- Handicapped (HC)

INTERCHANGE INTERSECTION (II)

Definition - The area that encompasses the junction where a ramp terminus and the cross street (LX) intersect within the Interchange area.

INTERCHANGE AREA

The Interchange Area (pictured below) is comprised of numerous Intersections Areas. Included are Interchange Ramp Intersections as well as Interchange Intersections. The Interchange Area will be assigned an Interchange Number.

INTERCHANGE NUMBER

All Interchanges will be assigned a 5 character number. All Intersections within the Interchange Area will relate to the Interchange by way of the Interchange Number.

Interchange Intersections will also receive a 5 character, computer assigned number. Both the Interchange and Interchange Intersection numbers will be unique and will not be repeated.

All data relating to a particular Interchange will key on its unique number.

INTERCHANGE INTERSECTION AREA

The Interchange Intersection Area (outlined in red) will be located by a single point known as the Interchange Intersection Point.

The shape of the Interchange Intersection Area will vary depending on the Intersection configuration.

INTERCHANGE INTERSECTION POINT

The Interchange Intersection Point is the point in the center of the Interchange Intersection area (outlined in red). This point will be assigned a unique number that will carry with it all the intersection attributes.

A single coordinate value will be collected at the Interchange Intersection Point. An ARM value for both increasing and decreasing milepost directions will also be collected. An Interchange Intersection point will be collected for each Interchange Intersection within Interchange Area.

MOST COMMON NAME

The most common name of an Interchange Intersection will be recorded. For example:

SR 101 NB Off Ramp and SR 003

An alternate name can also be recorded if needed.

GENERAL INTERSECTION ENVIRONMENT

Of the General Environmental Types listed below, select the type that best describes the character of the area.

General Environment Types

- Urban
- Rural
- Suburban - Mixed

INTERCHANGE INTERSECTION ILLUMINATION

Indicate whether Illumination is present at the Intersection by selecting "Yes" or "No".

INTERCHANGE INTERSECTION LEG

Definition - The approach and departure lanes comprising an Interchange Intersection Area that flow from a specific compass direction.

Intersection data will be collected by MP direction (inc./dec.), according to the Leg(s) associated with the MP direction. Each Leg will have approach and departure lanes of varying types, e.g., ramp, turn, acceleration, general purpose, etc.

The following information will be collected by Leg.

LEG NAME

The most common Leg Name will be recorded. The name will have to be truncated if it exceeds 18 characters. An alternative name can also be recorded.

LEG LANE TYPES

One or more of the following Lane Types will be found at Standard Intersections.

General Purpose (GP)

Also called through lanes, General Purpose Lanes are the main lanes of travel of a State Route.

Auxiliary (AX)

Auxiliary Lanes are less than 1 mile in length and typically extend from an on ramp to the next off ramp, or from intersection to intersection.

Ramp (RP)

An On or Off Ramp will carry the appropriate RRT and RRQ. They are considered lane types for both the Geometric and Intersection Runs.

Interchange Intersection Ramp

Types

- On Ramp (ON)
- Off Ramp (OF)
- On/Off (OO)

Bicycle (BL)

Bicycle Lanes are delineated by a 6" white stripe, signed and/or marked with a Preferential Lane Symbol and/or the standard bicycle symbol and are from 4' to 10' wide.

CHANNELIZED / PROTECTED LANES

Turn (TN)

Turn Lanes are those lanes that direct traffic by way of pavement markings and/or delineation into a turning movement.

Turn Lanes will require the following additional information:

Channelization

Types

- Raised Island (RI)
- Painted Island (PI)

Lane Protection

Types

- Protected/Permissive left turn (PP)
- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)
- None (NN)

Acceleration Lane (AL)

Acceleration Lanes are defined as a Lane with enough length to allow a vehicle to reach highway speed prior to merging into a through lane, and are typically utilized following a right turn Lane.

Acceleration Lanes will require the following additional information:

Lane Protection

Types

- Protected/Permissive left turn (PP)
- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)
- None (NN)

ALTERNATE USE LANES

HOV (HV)

High Occupancy Vehicle (HOV) Lanes are signed, and marked with a Preferential Lane Symbol (diamond).

Transit (TR)

Transit Lanes are signed and restricted to Transit only.

Alternate Use Type - Record use hours: From_____ To_____ for Alternate Use approach and departure Lanes.

Collection Procedures

The type of Lane, beginning and ending ARM values, number of Lanes, width and surface type will be collected for all Lane types. At areas other than Intersections, lane data will be collected as a part of the geometrics record (see section on Geometrics Run).

LANE WIDTHS

Definition - The width of a lane from center of stripe to center of stripe.

Collection Procedures

Lane widths will be measured from the yellow stripe to fogline (white stripe), from fogline to skip-stripe, or from skip-stripe to skip-stripe. An ARM value will be assigned at each change in width and a new width will be collected.

LANE NUMBER

Definition - The number associated with a lane occurring on a State Route Intersection Leg.

Collection Procedures

A Lane Number will be assigned to each Lane beginning with the number 1 which is always assigned to the outside lane. As new Lanes begin, the next consecutive number will be used. As a Lane is terminated, the highest number will be eliminated.

LANE SURFACE

Definition - The top layer of material occurring on the General Purpose travel lanes of a State Route.

Surface Types

- Asphalt (A)
- Bituminous (B)
- Portland Concrete Cement (P)
- Gravel (G)

Collection Procedures

Lane Surfaces will be collected by way of visual assessment. An ARM value will be collected at all changes in surface conditions.

LEG LANE MOVEMENT TYPE

The following Movement Types will be assigned to each Leg Lane:

Movement Types

- Thru (TU)
- Left (LT)
- Right (RT)
- Thru-Left (TL)
- Thru-Right (TR)

LEG COMPASS DIRECTION

The Compass Direction will be collected for each Leg. Eight Compass Directions are available. They are:

- N (1)
- NE (2)
- E (3)
- SE (4)
- S (5)
- SW (6)
- W (7)
- NW (8)

TRAFFIC CONTROL

One of the following Traffic Control Types will be collected for each leg:

- Signalized (SG)
- Stop Sign (SS)
- School Zone (SZ)
- Red Flashing (RF)
- Amber Flashing (AF)
- Yield Sign (YS)
- Railroad Signal (RS)
- Pedestrian Control (PC)
- Fire Signal (FS)
- Officer/Flagger (OF)
- None (NN)

RAILROAD CROSSING WITHIN 200 FEET OF INTERSECTION

Select indicator if a Railroad Crossing exists on the cross street within 200 ft. of intersection. Railroads that cross a state highway will be collected in more detail (described later in this section).

SURROUNDING ENVIRONMENT

- Central business district (CB)
- Strip commercial area (SC)
- Shopping center (SH)
- Industrial area (IA)
- Residential area (RA)
- School (SH)
- School crossing (SX)
- Agricultural (AG)
- Emergency service (ES)
- Park (PK)
- Campground (CG)
- Recreational, e.g., golf course (RC)
- Elderly (EL)
- Handicapped (HC)

RAMP INTERSECTION (RI)

Definition - The area that encompasses the junction where a ramp and the mainline intersect within the Interchange area.

INTERCHANGE AREA

The Interchange Area (pictured below) is comprised of numerous Intersections Areas, including Ramp Intersections.

INTERCHANGE NUMBER

All Interchanges will be assigned a 5 character number. All Intersections within the Interchange Area will relate to the Interchange by way of the Interchange Number.

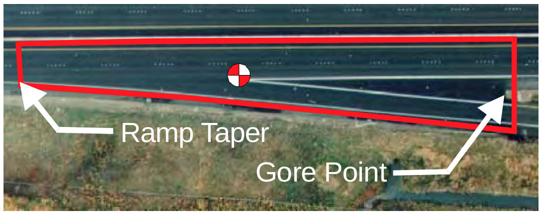
Ramp Intersections will also receive a 5 character, computer assigned number. Both the Interchange and Ramp Intersection numbers will be unique and will not be repeated. All data relating to a particular Ramp Intersection will key on its unique number.

RAMP INTERSECTION AREA

The Ramp Intersection Area (outlined in red) will be located by a single point known as the Ramp Intersection Point.

The shape of the Ramp Intersection Area will vary depending on the Intersection configuration.

The Ramp Intersection Area is defined by the beginning of the taper, to the Gore Point, and from the outside of the Ramp to the inside lane stripe (yellow) for both increasing and decreasing.



RAMP INTERSECTION POINT

The Ramp Intersection Point is the point in the center of the Ramp Intersection area (outlined in red).

This point will be assigned a unique number that will carry with it all the intersection attributes. A single coordinate value and an ARM value will be collected at each Ramp Intersection Point. An Ramp Intersection point will be collected for each Ramp Intersection within Interchange Area.

An XYZ and ARM value will be collected at the Gore Point as well as the Taper Point.

MOST COMMON NAME

The most common name of an Interchange Intersection will be recorded. For example:

SR 101 NB Off Ramp and SR 003

An alternate name can also be recorded if needed.

GENERAL INTERSECTION ENVIRONMENT

Of the General Environmental Types listed below, select the type that best describes the character of the area.

General Environment Types

- Urban
- Rural
- Suburban - Mixed

INTERCHANGE INTERSECTION ILLUMINATION

Indicate whether Illumination is present at the Intersection by selecting "Yes" or "No".

INTERCHANGE INTERSECTION LEG

Definition - The approach and departure lanes comprising an Interchange Intersection Area that flow from a specific compass direction.

Intersection data will be collected by MP direction (inc./dec.), according to the Leg(s) associated with the MP direction. Each Leg will have approach and departure lanes of varying types, e.g., ramp, turn, acceleration, general purpose, etc.

The following information will be collected by Leg.

LEG NAME

The most common Leg Name will be recorded. The name will have to be truncated if it exceeds 18 characters. An alternative name can also be recorded.

LEG LANE TYPES

One or more of the following Lane Types will be found at Standard Intersections.

General Purpose (GP)

Also called through lanes, General Purpose Lanes are the main lanes of travel of a State Route.

Auxiliary (AX)

Auxiliary Lanes are less than 1 mile in length and typically extend from an on ramp to the next off ramp, or from intersection to intersection.

Ramp (RP)

An On or Off Ramp will carry the appropriate RRT and RRQ. They are considered lane types for both the Geometric and Intersection Runs.

Interchange Intersection Ramps

Types

- On Ramp (ON)
- Off Ramp (OF)
- On/Off (OO)

Bicycle (BL)

Bicycle Lanes are delineated by a 6” white stripe, signed and/or marked with a Preferential Lane Symbol and/or the standard bicycle symbol and are from 4’ to 10’ wide.

CHANNELIZED / PROTECTED LANES

Turn (TN)

Turn Lanes are those lanes that direct traffic by way of pavement markings and/or delineation into a turning movement.

Turn Lanes will require the following additional information:

Channelization

Types

- Raised Island (RI)
- Painted Island (PI)

Lane Protection

Types

- Protected/Permissive left turn (PP)
- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)
- None (NN)

Acceleration Lane (AL)

Acceleration Lanes are defined as a Lane with enough length to allow a vehicle to reach highway speed prior to merging into a through lane, and are typically utilized following a right turn Lane.

Acceleration Lanes will require the following additional information:

Lane Protection

Types

- Protected/Permissive left turn (PP)
- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)
- None (NN)

ALTERNATE USE LANES

HOV (HV)

High Occupancy Vehicle (HOV) Lanes are signed, and marked with a Preferential Lane Symbol (diamond).

Transit (TR)

Transit Lanes are signed and restricted to Transit only.

Alternate Use Type - Record use hours: From_____ To_____ for Alternate Use approach and departure Lanes.

Collection Procedures

The type of Lane, beginning and ending ARM values, number of Lanes, width and surface type will be collected for all Lane types. At areas other than Intersections, lane data will be collected as a part of the geometrics record (see section on Geometrics Run).

LANE WIDTHS

Definition - The width of a lane from center of stripe to center of stripe.

Collection Procedures

Lane widths will be measured from the yellow stripe to fogline (white stripe), from fogline to skip-stripe, or from skip-stripe to skip-stripe. An ARM value will be assigned at each change in width and a new width will be collected.

LANE NUMBER

Definition - The number associated with a lane occurring on a State Route Intersection Leg.

Collection Procedures

A Lane Number will be assigned to each Lane beginning with the number 1 which is always assigned to the outside lane. As new Lanes begin, the next consecutive number will be used. As a Lane is terminated, the highest number will be eliminated.

LANE SURFACE

Definition - The top layer of material occurring on the General Purpose travel lanes of a State Route.

Surface Types

- Asphalt (A)
- Bituminous (B)
- Portland Concrete Cement (P)
- Gravel (G)

Collection Procedures

Lane Surfaces will be collected by way of visual assessment. An ARM value will be collected at all changes in surface conditions.

LEG LANE MOVEMENT TYPE

The following Movement Types will be assigned to each Leg Lane:

Movement Types

- Thru (TU)
- Left (LT)
- Right (RT)
- Thru-Left (TL)
- Thru-Right (TR)

LEG COMPASS DIRECTION

The Compass Direction will be collected for each Leg. Eight Compass Directions are available. They are:

- N (1)
- NE (2)
- E (3)
- SE (4)
- S (5)
- SW (6)
- W (7)
- NW (8)

TRAFFIC CONTROL

One of the following Traffic Control Types will be collected for each leg:

- Signalized (SG)
- Stop Sign (SS)
- School Zone (SZ)
- Red Flashing (RF)
- Amber Flashing (AF)
- Yield Sign (YS)
- Railroad Signal (RS)
- Pedestrian Control (PC)

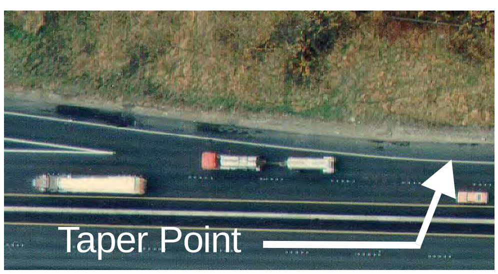
- Fire Signal (FS)
- Officer/Flagger (OF)
- None (NN)

PHYSICAL GORE

Definition - The point between two lanes of travel, e.g., mainline and a ramp, where a vehicle can no longer access one from the other.

Collection Procedures

The Physical Gore will be collected at the point in the center of the gore area where a vehicle can no longer access one travelway from another (typically where the asphalt meets natural ground). An ARM value, as well as XYZ will be collected at the Physical Gore.



TAPER POINT

The Taper Point is the point at the beginning or end of the ramp (stripe angles from mainline or to mainline). An ARM value and XYZ coordinates will be collected at the Taper Point.

ACCESS INTERSECTION (AI)

Definition - The area that encompasses the junction where a State Route intersects with a travelway designed for access to or from an identified dwelling or facility type.

INTERSECTION NUMBER

Access Intersections will receive a unique 5 character, computer assigned number. All data relating to a particular Access Intersection will key on its unique number.

ACCESS INTERSECTION AREA

Due to the potential for overlap of Access Intersection Areas which would result in duplicated effort, the Intersection area for Access Intersections will be restricted to either the increasing or decreasing side of the highway.

The assignment of the Access Intersection to either the increasing or decreasing direction will depend on the location of the driveway. If the driveway is on the increasing side, it will be inventoried using increasing mileposts, likewise with decreasing.

ACCESS INTERSECTION POINT

The Access Intersection Point is the point in the center of the Access Intersection area (outlined in red). As mentioned above, this point will be assigned a unique number that will carry with it all the intersection attributes.

A single coordinate value will be collected at the Access Intersection Point. An ARM value for the milepost direction (inc. or dec.) will also be collected. An Access Intersection Point will be collected for each Access Intersection.

ACCESS INTERSECTION TYPES

One of the following Access Intersection Types will be selected for each Access Intersection.

- Residential Driveway (RD)
- Multi-Residential Driveway (MR)
- Commercial Driveway (CD)
- Residential - Commercial Driveway (RC)
- Rest Area (RA)
- Park and Ride (PR)
- View Point (VP)
- Information Center (IC)
- Weigh Station (WS)
- Ferry Terminal (FT)
- Toll Booth (TB)
- Recreation Area (RE)
- Flyer Stop (FS)
- Transit Stop (TS)

ACCESS TYPE

Exit To
Entrance From
Exit To/Entrance From

GENERAL ENVIRONMENT

Of the General Environmental Types listed below, select the type that best describes the character of the area.

General Environment Types

- Urban
- Rural
- Suburban - Mixed

ACCESS INTERSECTION LEG

Definition - A combination of lanes, including approach and departure, by MP direction, that flow to and from an intersection from a specific compass direction.

Access Intersection data will be collected by MP direction (inc./dec.), according to the Leg(s) associated with the MP direction. Each Leg of an Access Intersection will have approach and departure lanes of varying types, e.g., turn, acceleration, general purpose, etc.

The following information will be collected by Leg.

LEG NAME

The most common Leg Name will be recorded. The name will have to be truncated if it exceeds 18 characters. An alternative name can also be recorded.

LEG LANE TYPES

One or more of the following Lane Types will be found at Standard Intersections.

General Purpose (GP)

Also called through lanes, General Purpose Lanes are the main lanes of travel of a State Route.

Auxiliary (AX)

Auxiliary Lanes are less than 1 mile in length and typically extend from an on ramp to the next off ramp, or from intersection to intersection.

Bicycle (BL)

Bicycle Lanes are delineated by a 6” white stripe, signed and/or marked with a Preferential Lane Symbol and/or the standard bicycle symbol and are from 4’ to 10’ wide.

CHANNELIZED / PROTECTED LANES

Turn (TN)

Turn Lanes are those lanes that direct traffic by way of pavement markings and/or delineation into a turning movement.

Turn Lanes will require the following additional information:

Channelization

Types

- Raised Island (RI)
- Painted Island (PI)

Lane Protection

Types

- Protected/Permissive left turn (PP)
- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)
- None (NN)

Acceleration Lane (AL)

Acceleration Lanes are defined as a Lane with enough length to allow a vehicle to reach highway speed prior to merging into a through lane, and are typically utilized following a right turn Lane.

Acceleration Lanes will require the following additional information:

Lane Protection

Types

- Protected/Permissive left turn (PP)

- Protected (same as opposing left turn) (PS)
- Protected (no opposing left turn @ same time) (PN)
- None (NN)

ALTERNATE USE LANES

HOV (HV)

HOV Lanes are signed, and marked with a Preferential Lane Symbol (diamond).

Transit (TR)

Transit Lanes are signed and restricted to Transit only.

Alternate Use Type - Record use hours: From_____ To_____ for Alternate Use approach and departure Lanes.

Collection Procedures

The type of Lane, beginning and ending ARM values, number of Lanes, width and surface type will be collected for all Lane types. At areas other than Intersections, lane data will be collected as a part of the geometrics record (see section on Geometrics Run).

LANE WIDTH

Definition - The width of a lane from center of stripe to center of stripe.

Collection Procedures

Lane widths will be measured from the yellow stripe to fogline (white stripe), from fogline to skip-stripe, or from skip-stripe to skip-stripe. An ARM value will be assigned at each change in width and a new width will be collected.

LANE NUMBER

Definition - The number associated with a lane occurring on a State Route Intersection Leg.

Collection Procedures

A Lane Number will be assigned to each Lane beginning with the number 1 which is always assigned to the outside lane. As new Lanes begin, the next consecutive number will be used. As a Lane is terminated, the highest number will be eliminated.

LANE SURFACE

Definition - The top layer of material occurring on the General Purpose travel lanes of a State Route.

Surface Types

- Asphalt (A)
- Bituminous (B)
- Portland Concrete Cement (P)
- Gravel (G)

Collection Procedures

Lane Surfaces will be collected by way of visual assessment. An ARM value will be collected at all changes in surface conditions.

LEG LANE MOVEMENT TYPE

The following Movement Types will be assigned to each Leg Lane:

Movement Types

- Thru (TH)
- Left (LT)
- Right (RT)
- Thru-Left (TL)
- Thru-Right (TR)

LEG COMPASS DIRECTION

The Compass Direction will be collected for each Leg. Eight Compass Directions are available. They are:

- N (1)
- NE (2)
- E (3)
- SE (4)
- S (5)
- SW (6)
- W (7)
- NW (8)

TRAFFIC CONTROL

One of the following Traffic Control Types will be collected for each leg:

- Signalized (SG)
- Stop Sign (SS)
- School Zone (SZ)
- Red Flashing (RF)
- Amber Flashing (AF)
- Yield Sign (YS)
- Railroad Signal (RS)
- Pedestrian Control (PC)
- Fire Signal (FS)
- Officer/Flagger (OF)
- None (NN)

SURROUNDING ENVIRONMENT

The Surrounding Environment will also be determined according milepost direction for each Leg.

- Central business district (CB)
- Strip commercial area (SC)
- Shopping center (SH)
- Industrial area (IA)
- Residential area (RA)
- School (SH)
- School crossing (SX)

- Agricultural (AG)
- Emergency service (ES)
- Park (PK)
- Campground (CG)
- Recreational, e.g., golf course (RC)
- Elderly (EL)
- Handicapped (HC)

NON INTERSECTION TRAFFIC CONTROL DEVICE

Definition - A device used to regulate or control the flow of traffic at areas other than intersections.

Types of Traffic Control:

- Signalized (SG)
- Stop Sign (SS)
- Other Traffic Control (OT)
- School Zone (SZ)
- Red Flashing (RF)
- Amber Flashing (AF)
- Yield Sign (YS)
- Railroad Signal (RS)
- No Traffic Control (NO)
- Pedestrian Control (PC)
- Fire Signal (FS)
- Officer / Flagger (OF)

Collection Procedures

The Non-Intersection Traffic Control Device data will not be a part of the intersection record. The intent is to allow the capture of Traffic Control devices that occur at non-intersection, e.g. mid-block crosswalks, fire station signals, etc.

Traffic Control will be located by way of ARM for both increasing and decreasing milepost directions. All applicable Traffic Control devices will be located as sign support or support pole records.

CROSSWALK

Definition - Pavement markings that delineate an area used by pedestrians to cross a street.

Types of Crosswalks:

- Ladder Stripe (LS)
- Edge Line (EL)
- Diagonal (DI)
- Zebra (ZE)

Collection Procedures

The ARM value, crosswalk type, material type (if known), presence of a pedestrian display (yes / no indicator), presence of an audio signal (yes / no indicator), and the width will be collected at all Crosswalks.

Material types include: Plastic, paint and unknown.

RAILROAD CROSSING

Definition - A location where train tracks traverse a State Route.

The following describes the collection of Railroad Crossings that cross a State Route (not to be confused with R/R Xings that are within 200' of an intersection).

All information pertaining to R/R Xings is kept in a data base that is maintained by the Travel Data Collection Section and the TDO.

Collection Procedures

We will be collecting the ARM value, traffic control type, XYZ coordinates, the owner ID code (if known) and the AAR Number for all Railroad Crossings that traverse a State Route.

AAR Number

The AAR Number (a.k.a. DOT Number) can be found in several locations at the crossing. Typically it is found on the vault (picture at far left), on the gate or on the signal pole (picture at right). The AAR Number is important since it carries with it all information pertinent to the crossing.

Traffic Control Types

- Signalized
- Signalized with Gate
- Stop Sign
- None

STRUCTURES & BARRIER RUN

This chapter describes the methods of identification and collection procedures for Structures and Barriers.

The Structures and Barrier Run is unique in that a portion of the data collected for all Bridges (as a part of the Control Run) will automatically placed in the ROAD Database as a Structure Type. This data will remain as an incomplete record until the remaining data is collected during the Structures and Barrier Run.

STRUCTURES

Structure Types

- Bridge (B)
- Overhead Bridge (O)
- Tunnel (T)
- Pedestrian Bridge (P)

BRIDGE

Definition - A type of structure occurring on a State Route that allows traffic to cross over an otherwise untraversable object or area, and/or aids in the flow of traffic by elevating one road over another.

Collection Procedures

Bridge Seat data will be collected as a part of the Control Run (see section on Control Run). The averaged ARM values will automatically be placed in the Structures table when they are saved. Coordinate values will be gathered separately from the Control Run and will be collected at the beginning and end of the Structure, where the Bridge Seats meet the fogline.

OVERHEAD BRIDGE

Definition - A bridge which a State Route passes under.

Collection Procedures

Overhead Bridge (Under Crossing) mileposts will be collected at the beginning and end of the structure. GPS coordinates will be collected on the structure where the fogline crosses under the bridge at both the beginning and end of the structure.

TUNNEL

Definition - A structure which allows a State Route to pass through an obstacle.

Collection Procedures

Tunnel ARM values will be collected at the beginning and end of the structure. GPS coordinates will be collected at a point where the fogline crosses under the overhead structure at both the beginning and end.

Although a Snow Shed (Lake Keechellis Snow Shed pictured at left) is not technically a tunnel, it will be collected and entered into the system as a Tunnel with a description indicating that it is a Snow Shed.

BARRIER

Definition - A physical device to prevent vehicles from leaving a State Route.

Barrier Types

The following is a list of Barrier and Barrier Sub-types that will be collected.

Jersey (JB)

Precast (PC)

Typically an unrestrained or Precast barrier will have 10’ to 12’-6” sections with pin connections.

Cast in Place (CIP)

Unlike the precast barrier, the restrained or Cast in Place barrier is a continuous barrier (with no pin connections) that was formed in the field. Several different shapes exist.

A "pony" or "stub" wall (several feet high) is sometimes cast as a part of the barrier.

END TREATMENT TYPES

Buried Terminal (BT)

Unlike the Berm end treatment, the Buried end treatment terminates in the side slope.

Berm (BM)

The barrier terminates into a built-up mound of earthen material.

Sloped Down (SD)

A concrete end section that tapers from top to bottom in one or more section length(s).

IMPACT ATTENUATOR TYPES

For photos and descriptions of the various types, see Guardrail section - Impact Attenuators.

Glare Screen (GS)

Indicate whether a Glare Screen is present on either a Jersey Barrier or Guardrail by selecting "yes" or "no".

Glare Screen Types

Paddles (P)
Chain link (CL)

RAISED BARRIER (RB)

Any raised median area is considered a Raised Barrier.

DEPRESSED (DE)

Any depressed median area is considered a Depressed Barrier.

GUIDE POSTS (GP)

Not to be confused with the flexible delineators, Guide Posts typically have a metal post when used on the shoulder, or a metal base and flexible tube when used for channelization.

CURB (CU)

Curb, whether associated with a sidewalk or not will be collected.

WALL

Walls will be collected and categorized under one of the two following types.

Wall Types

Acoustical (AW)

Acoustical Walls, or noise walls are constructed for sound barrier purposes.

Retaining (RW)

The Gabion Wall shown at left is an example of a Retaining Wall. Retaining Walls are constructed primarily to stabilize or "retain" a slope.

Retaining Wall Types

Listed below are the various types of Retaining Walls. The field crew is not expected to identify each type as it occurs in the field. The types are listed as a reference only. An illustration of the types can be found in Figure 1130-1a of WSDOT's *Design Manual*.

- Cantilever
- Counterfort
- Soil Nailing
- Soldier w/Tieback
- Slurry & Cylinder
- Gabion
- Metal Cribbing
- Geotextile
- Rock
- Mechanically Stabilized Earth
- Precast Concrete Cribbing

Collection Procedures

Collection procedures for all Barrier Types will be as follows:

The begin / end arm and XYZ values for Barrier will be collected at a point where the where the end treatment (if exists) begins and/or terminates.

Intermediate points will be collected using the following guidelines:

Tangent - Every 50 to 100 feet depending on length.
Curve - Every 25 to 50 feet depending on radius.

The Barrier Type Code, End Treatment and Offset from fogline will also be collected.

GUARDRAIL

Definition - A physical device to prevent vehicles from leaving a State Route.

Collection Procedures

The begin / end arm and XYZ values for Guardrail will be collected at a point where the Guardrail begins and where the end treatment (if any) terminates. Intermediate points will be collected using the following guidelines:

Tangent - Every 50 to 100 feet depending on length.
Curve - Every 25 to 50 feet depending on radius.

The Guardrail Type Code, Post Type and Spacing, End Treatment and Offset from fogline will also be collected.

GUARDRAIL TYPE

W-Beam (WB)

W-Beam is the most common type of guardrail rail in Washington State. A cross section of the rail would appear as a "W", thus the name "W-Beam.

W-BEAM OPTIONAL FEATURES

Double Sided (DS)

Indicate whether present by selecting "yes" or "no".

Rub Rail (RR)

Indicate whether present by selecting "yes" or "no".

Thrie Beam (TB)

Thrie Beam rail is most commonly found on bridges.

Cable (CA)

Fairly uncommon, 3 cables and steel posts make up this guardrail type.

Timber (TI)

Timber guardrails are rare. They can still be found in some places such as State or National Parks.

No Picture Available

Flex Beam (FB)

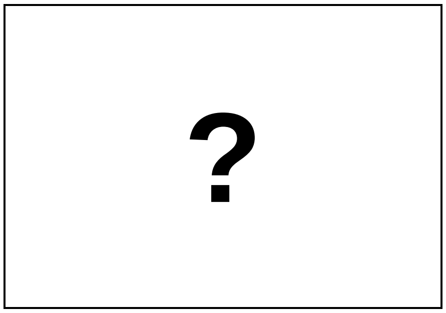
No information available.

C-Shaped (CS)

Some occurrences of C-Shaped rail still exist throughout the state. C-Shaped rail will typically be mounted to concrete posts.

Flanged W-Beam (FB)

Also found mounted to concrete posts, the Flanged W-Beam will have distinct flanges on the top and bottom of rail.



Unknown

Any Unknown types will be photographed. Photos will be reviewed in the office and a type will be assigned.

GUARDRAIL POST OPTIONS

A Guardrail Post Type will be collected by way of visual assessment and must be selected from the following list of types.

Post Type

Wood

Steel

Concrete

Post Spacing

12’-6” Spacing

No posts between rail splices. Usually no blockouts.

6’-3” Spacing

This is the most common spacing.

3’-1 1/2” Spacing

This spacing will usually have larger posts.

END TREATMENT TYPES

Slotted Rail Terminal (SR)

Similar to a W-Beam, this rail will have slots in rail. End is typically flared from roadway.

Breakaway Cable Terminal (BC)

There are no Slots in this type. The 2nd post will have a hole at groundline. The end will be flared from roadway.

Nonflared Terminal (NF)

Square end piece will be obvious.

Buried Terminal (BT)

The guardrail end will be buried in the slope.

Bullnose (BN)

This rail will curve around an open area, e.g., between two bridges. The center post is usually smaller than normal. Cable anchors exist on each side.

Eccentric Loader (EL)

Corregated pipe end section will be obvious.

?

Unknown (UN)

Any Unknown types will be photographed. Photos will be reviewed in the office and a type will be assigned.

IMPACT ATTENUATORS (IA)

The following Impact Attenuators will be selected (when appropriate) for Guardrail and Barrier End Treatment types.

Impact Attenuator Types

GREAT (GT)

Note: Thrie beam (triple corregated) fender panels. Square cartridges

QuadGuard (QG)

Note: Quad Beam (quadruple corregated fender panels). Square cartridges.

LMA (LA)

Note: Thrie beam (triple corregated) fender panels. Round diaphragms.

The only LMA in use in Washington is at the I-5 SB / SR 16 gore.

ADIEM (AD)

REACT 350 (RE)

BrakeMaster (BM)

Note: Double sided W-beam guardrail, steel posts.

Sentre / TREND (ST)

Note: Thrie beam fender panels, sand containers at front of system, anchor cable in back of system.

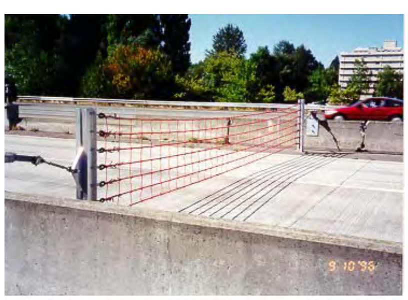
CAT (CT)

Note: Double sided W-beam guardrail with slots on corregations, wood posts.

Hex Foam Sandwich (HF)

Note: Flat fender panels.

Inertial Barriers (IB)



Dragnet (DN)

PIER

Definition - A support device used to hold up an overhead bridge that occurs on a State Route.

Collection Procedures

The ARM, XYZ and L/R indicator for Piers will be collected at all Overhead Bridges where visible Piers exist, whether protected by barrier or not.

ADIEM (AD)

REACT 350 (RE)

BrakeMaster (BM)

Note: Double sided W-beam guardrail, steel posts.

Sentre / TREND (ST)

Note: Thrie beam fender panels, sand containers at front of system, anchor cable in back of system.

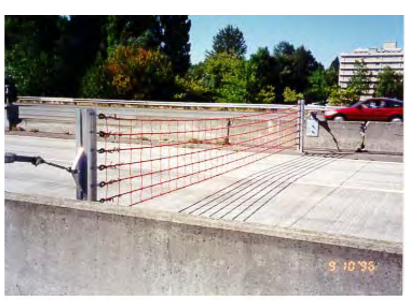
CAT (CT)

Note: Double sided W-beam guardrail with slots on corregations, wood posts.

Hex Foam Sandwich (HF)

Note: Flat fender panels.

Inertial Barriers (IB)



Dragnet (DN)

PIER

Definition - A support device used to hold up an overhead bridge that occurs on a State Route.

Collection Procedures

The ARM, XYZ and L/R indicator for Piers will be collected at all Overhead Bridges where visible Piers exist, whether protected by barrier or not.

THE GEOMETRICS RUN

The Geometrics Run consists primarily of Lanes, Shoulders, Medians, and their attributes. Geometric configurations that exist upon approach to an intersection will be carried through the intersections. Any additional lanes that continue beyond the intersection will be collected as a part of the Geometrics Run.

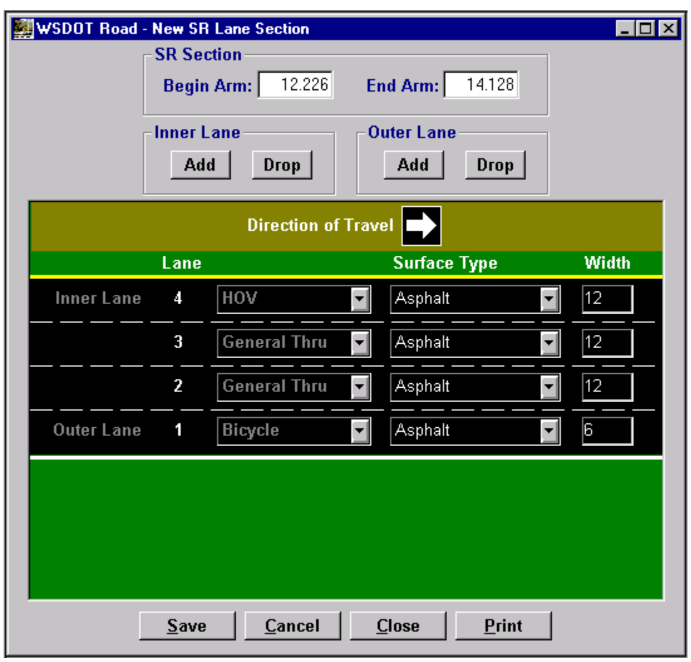
LANES

Definition - That portion of the travelway of a State Route which restricts traffic movement to one line of vehicles by way of markings or delineation.

The various Lanes that constitute the mainline of a State will be collected by using a numbering system. The Lane Type, Width and Surface Types will all be tied to the Lane Number. The Lane Numbers are assigned using the following criteria.

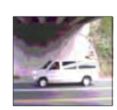
LANE NUMBER

Definition - The number associated with a lane occurring on a State Route Intersection Leg.

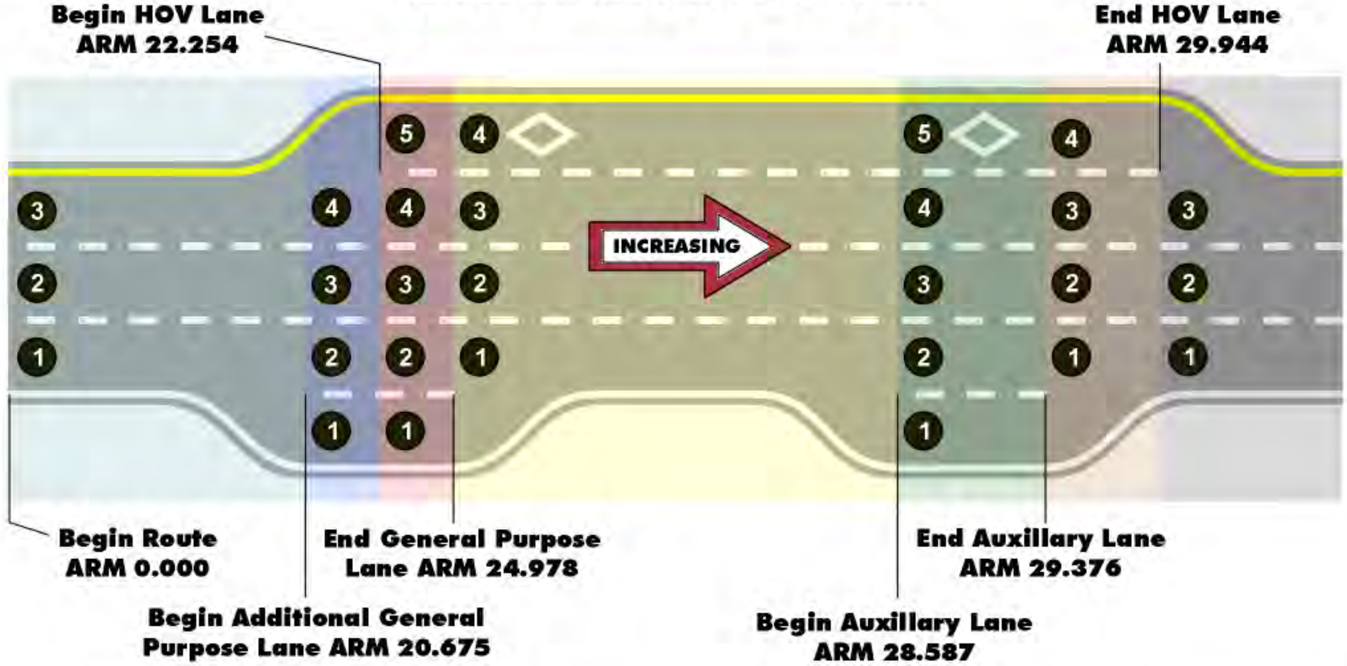


Collection Procedures

A Lane Number will be assigned to each Lane beginning with the number 1 which is always assigned to the outside lane. The Lane Type, Surface Type and Width will be recorded for each lane. As new Lanes begin, the next consecutive number will be used. As a Lane is terminated, the highest number will be eliminated. The data entry screen (shown at left) allows the operator to view the current highway configuration.



LANE NUMBERING SYSTEM



At the beginning of the route (ARM 0.000) there are three GP Lanes. They are numbered from right to left, as seen facing the direction of travel.

Lanes are re-numbered where a full lane of travel is added. Notice this happens at ARM 20.675, the point where the additional General Purpose Lane is full width.

Lanes are re-numbered at the beginning of the HOV lane (ARM 22.254). Again at the beginning of the full width of the lane, from right to left facing the direction of travel.

At the point where the end General Purpose Lane taper begins, ARM 24.978, a new Lane section is entered into the system consisting of 3 - GP Lanes and 1 - HOV Lane.

With the addition of an Auxilliary Lane at ARM 28.587, a new section must be entered into the system consisting of 1 - Auxilliary Lane, 3 - GP Lanes and 1 - HOV Lane.

At the point where the end Auxilliary Lane taper begins, ARM 29.376, a new Lane section is entered into the system consisting of 3 - GP Lanes and 1 - HOV Lane.

At the point where the end HOV Lane taper begins (ARM 29.944), a new Lane section is entered into the system consisting of 3 - GP Lanes.

Note: The Lane numbering system shown here does not represent Lane configurations at intrersections which are shown elsewhere.

Lane Types

General Purpose (GP)

Also called through lanes, General Purpose Lanes are the main lanes of travel of a State Route.

Auxiliary (AX)

Auxiliary Lanes are less than 1 mile in length and typically extend from an on ramp to the next off ramp, or from intersection to intersection.

Bicycle (BL)

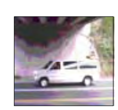
Bicycle Lanes are delineated by a 6” white stripe, signed and/or marked with a Preferential Lane Symbol and/or the standard bicycle symbol and are from 4’ to 10’ wide.

Chain Up (CU)

Chain Up areas are found in areas where a State Route is approaching a pass. They are signed, located on the outside shoulder and vary in length and width.

Climbing (CL)

Climbing Lanes are found in areas where incline grades exist. A Climbing Lane will be the outside lane. Once the grade tapers off, the Climbing Lanes will typically end.



HOV (HV)

HOV Lanes are signed, and marked with a Preferential Lane Symbol (diamond).

Holding (HL)

Holding Lanes are found at ferry terminals and are used to store vehicles while awaiting a ferry.

Slow Vehicle Turnout (SV)

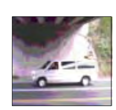
These areas are signed. Slow Vehicle Turnouts utilize the outside shoulder and are typically designed with enough length for a vehicle to pull over and stop, allowing traffic to pass.

Transit (TR)

Transit Lanes are signed and restricted to Transit only.

Truck Climbing Shoulder (TS)

Found at incline grades, a Truck Climbing Shoulder is wide enough to accommodate a tractor/trailer and will typically be signed.



2 Way Turn (TW)

A 2 Way Turn Lane is used by both increasing and decreasing milepost directions to facilitate left turns.

Collection Procedures

The type of lane, beginning and ending ARM values, surface type and width will be collected for all Lane types. At intersections, lane data will be collected as a part of the intersection record (see section on Intersection Run).

LANE WIDTHS

Definition - The width of a lane from center of stripe to center of stripe.

Collection Procedures

Lane widths will be measured from the yellow stripe to fogline (white stripe), from fogline to skip-stripe, or from skip-stripe to skip-stripe. An ARM value will be assigned at each change in width and a new width will be collected.

LANE SURFACE

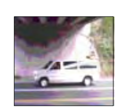
Definition - The top layer of material occurring on the General Purpose travel lanes of a State Route.

Types

- Asphalt (A)
- Bituminous (B)
- Portland Concrete Cement (P)
- Gravel (G)
- Grated Bridge Deck (GD)

Collection Procedures

Lane Surfaces will be collected by way of visual assessment. An ARM value will be collected at all changes in surface conditions.



SHOULDER

Definition - That portion of a State Route adjacent to the outside lane(s) of travel that occurs between the fogline and the edge of the surface area, and that is one foot or more in width.

The following attributes make up the Shoulder area. These attributes will be collected in both the increasing and decreasing directions, and will be given a right or left indicator.

Note: If a paved median exists, a left shoulder will not be recorded.

SHOULDER WIDTH

Collection Procedures

Shoulder Width will be collected from the beginning to the end of a State Route. The outside Shoulder Width will be collected along with the beginning and ending ARM values for both increasing and decreasing milepost directions. On divided highways, the inside Shoulder Width will be collected if median is other than paved (see section on Median). Any obvious and continuous change in width of more than one foot will be collected.

SHOULDER SURFACE

Definition - The top layer of material occurring on the shoulder of a State Route.

Type

- Asphalt (A)
- Soil (S)
- Portland Concrete Cement (P)
- Bituminous (B)
- Gravel (G)
- Unknown (U)

Collection Procedures

Shoulder Surface will be collected by way of visual assessment. An ARM value will be collected at all changes in Shoulder Surface.

MEDIAN

Definition - The area occurring on State Route between the increasing and decreasing lanes of travel of a divided highway.

The following attributes make up the Median Area. These attributes will be collected in relationship to the increasing direction only.

MEDIAN WIDTH

If the area between the increasing and decreasing lanes of travel of a divided highway is 4 ft. wide or greater, it is considered a Median.

Collection Procedures

- **Paved Median** - In areas where the median is paved, the width will be measured from yellow stripe (increasing) to yellow stripe (decreasing). The width will be recorded, as indicated above, in the increasing direction only.

- **Other than Paved** - In areas where the median is other than paved, the width will be measured from edge of shoulder (increasing) to edge of shoulder (decreasing). The width will be recorded, as indicated above, for both increasing and decreasing.

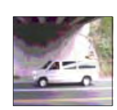
- **Paved with Barrier** - In areas where the median is paved with a barrier, the width will be measured from yellow stripe to the face of the barrier for both increasing and decreasing.

MEDIAN SURFACE

Definition - The top layer of material occurring in the median of a State Route.

Collection Procedures

Median Surface will be collected by way of visual assessment. An ARM value will be collected at all changes in Median Surface.



Types

- Soil (S)
- Bituminous (B)
- Gravel (G)
- Asphalt (A)
- Portland Concrete Cement (P)
- Unknown (U)

MEDIAN XING

Definition - An area used to traverse the median of a State Route

Collection Procedures

Official Median Crossings are determined by one or more of the following criteria:

- The crossing is paved.
- A “No U-Turn” sign is posted on one or both sides of the crossing.
- 3 flexible delineators will be located on the inside shoulder approaching the crossing.

An ARM value and XYZ will be collected for both increasing and decreasing directions and for both official and unofficial Median Crossings. The coordinate values will be taken where the center of the crossing and the fogline meet as illustrated above.

Types

- Official (O)
- Unofficial (UN)

RUMBLE STRIP

Definition - Objects or depressions placed on a State Route surface which are used to form a warning when crossed by a vehicle’s tires.

DEPRESSED (D)

Lateral (L)

Continuous (C)

The begin / end ARM and XYZ values as well as a left / right indicator for both increasing and decreasing directions will be collected.

Intermittent (I)

The begin / end ARM and XYZ values as well as a left / right indicator for both increasing and decreasing directions will be collected.

Transverse (T)

An ARM value and XYZ will be taken at a point where the Rumble Strip intersects the fogline.

RAISED (R)

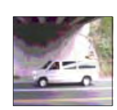
Raised Rumble Strip will be collected in the same manner as depressed, whether lateral or transverse, continuous or intermittent.

List of Types

Raised Transverse Int. (TC)
Raised Transverse Cont. (TI)
Raised Lateral Int. (RI)
Raised Lateral Cont. (RC)

Depressed Transverse Int. (DI)
Depressed Transverse Cont.(DC)
Depressed Lateral Int. (LI)
Depressed Lateral Cont. (LC)

SIDEWALK



Definition - A path alongside a State Route specifically designed for pedestrian use.

SIDEWALK TYPE

Streetside (ST)

Separated (SE)

- Plant Strip Type

  Ashpalt (A)
  Concrete (C)
  Soil (S)
  Grass (G)
  Unknown (U)

- Width of Separation

SURFACE TYPE

- Ashpalt (A)
- Concrete (C)
- Soil (S)
- Grass (G)

SIDEWALK CONDITION

- Good (G)
- Fair (F)
- Poor (P)

CURB CUT TYPE

- Straight (S)
- Diagonal (D)
- None (N)

Collection Procedures

In addition to the above information, the begin and end ARM will be collected as well as the location code (R / L indicator) and whether on the increasing or decreasing side of the highway.

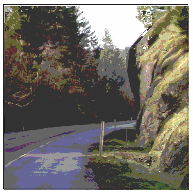
PHYSICAL GAP

Definition - The occurrence of a tangible break in milepost continuity along a state route.

Collection Procedures

An XYZ value will be collected at the begin and end points of the Physical Gap.

These 2 points can not be collected as a continuous line feature (GPS Mainline Run). The line feature must be stopped at the Begin Physical Gap and started again at the End Physical Gap in order to prevent an erroneous length. The ARM value will be the same for both the beginning and the end.



THE NATURAL ELEMENTS RUN

The Natural Elements Run consists primarily of features that can be associated with nature, e.g., water, trees, slopes, etc.

CULVERTS

Definition - A conduit for water beneath or alongside a State Route.

Initially, we will be collecting two basic types of culverts: Transverse (culverts that run beneath a highway), and Lateral (culverts that run alongside a highway).

Transverse culverts will be collected as "culvert ends". What this means is that only the ends will be located. In other words, a transverse culvert will not have a length associated with it. Due to the high potential for inaccurate length measurements (what is hidden under the highway would be difficult, at best, to measure), we will concentrate on locating the ends. If it can be determined whether a particular end is an outfall or an inlet, we will collect that information also.

CULVERT TYPES

The following are types of culverts we will be collecting.

- Round Culvert
- Box Culvert
- Arch Culvert

Each of the Culvert Types listed above will be collected under on of the following sub-types, and as one of 3 Material Types.

Transverse Culvert (CE)

Material Type

- Concrete (CO)
- Plastic (PL)

- Steel (ST)

Lateral Culvert (LC)

Material Type

- Concrete (CO)
- Plastic (PL)
- Steel (ST)

End Treatment Types

- Beveled End (BE)
- None (NO)

Collection Procedures

Location of these features will include: ARM values at both ends, XYZ at both ends, whether increasing or decreasing and a right / left indicator. We will also be collecting the diameter (in decimal feet), the type of culvert, material type and end treatment at both the inlet & outlet. If it can be determined, whether an end is an inlet or outlet will be indicated.

CATCH BASIN

Definition - A device used to hold storm water runoff along a State Route.

Collection Procedures

Location information (beg. / end ARM, XYZ, L / R indicator, offset from fogline), will be collected at this time. We anticipate collecting more detailed information, e.g., catch basing type, inlet type, storage capacity, etc.

DITCHES

Definition - Furrows, channels, trenches, swales, etc. that occur along a State Route.

The following types of Ditches will be collected.

Ditch Types

- Rock Fall (R)
- Drainage (D)
- Irrigation (I)

Collection Procedures

In addition to the type of Ditch, we will be collecting the following information: ARM value at the beginning and end of the Ditch, as well as intermediate points, the XYZ at the same points where the ARM values are taken, increasing or decreasing, left / right indicator, Ditch depth, offset to fogline (fogline to flowline of Ditch) and whether traversable or not.

WATER FEATURE

Definition - A body of water (river, lake, pond, etc.) occurring along a State Route.

Water Feature Types

- Lake (L)
- River (R)
- Creek (C)
- Wetland (W)
- Ocean / Bay (O)

Collection Procedures

We will collect data on all Water Features that fall within the collection limits of the area being inventoried. The type of water feature and location information will be collected.

TREES

Definition - Any flora with a trunk thickness of 3" or greater occurring in the median area or in the maximum clear zone area adjacent to a State Route.

Group

Information collected for Tree Groups will include location information, density (sparse, moderate & dense), and whether mixed or uniform (diameter).

Types

Dense Uniform (DU)	Dense Mixed (DM)
Moderate Uniform (MU)	Moderate Mixed (MM)
Sparse Uniform (SU)	Sparse Mixed (SM)

Isolated

Information collected for Isolated Trees will include location information. Isolated Trees will be collected if they are 3" diameter or greater.

SLOPES/EMBANKMENT

Definition - Hillsides, banks, inclines, etc. which occur along a State Route.

In addition to location information (beg. / end ARM, XYZ, L / R indicator, offset from fogline), the type of slope (cut or fill), the slope slant, and an indication of whether a rockfall screen is present will also be collected.

Slope Types

Cut (CU)

- Vertical (V)
- Steep (S)
- Moderate (M)

Fill (FI)

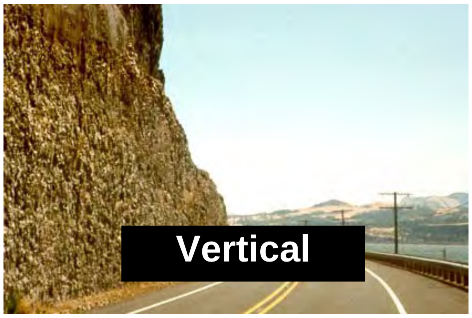
Steep (S)
Moderate (M)
Flat (F)

Fill Slopes

The following images are examples of Fill Slopes

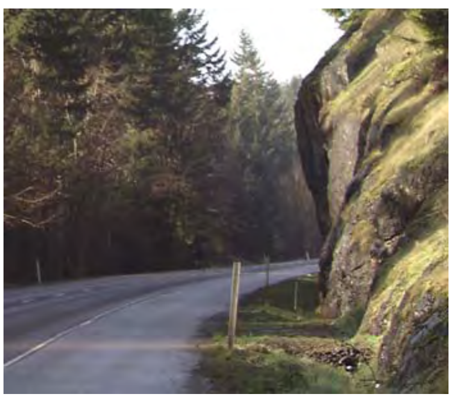
Cut Slopes

The following images are examples of Cut Slopes



ROCK OUTCROP

Definition - A natural formation of stone that protrudes toward a State Route.



Collection Procedures

Location information (beg. / end ARM, XYZ, L / R indicator, offset from fogline), will be collected for Rock Outcrop.

DEER REFLECTORS

Definition - A device along a State Route that catches the light from a vehicle's headlights and reflects the light in a manner that is intended to alarm a deer.

Collection Procedures

In addition to location information (beg. / end ARM, XYZ, L / R indicator, offset from fogline), the number of reflectors will also be collected.

TERRAIN

Definition - The contour of the roadway as it relates to the frequency and steepness of hills and the affect of truck speed.

Mountainous

The Mountainous areas are typically steep, rugged country. These areas cause trucks (tractor/trailers) to slow to a crawl frequently.

Rolling

Rolling Terrain is the most common. The majority of terrain in Washington fits into this category. The rolling designation is used when trucks slow down frequently.

Level

This area is generally used to describe the Terrain in urban areas and in the arid areas of Eastern Washington. Trucks are able to maintain speed in level areas.

Collection Procedures

Typically, the ROAD crew will be able to collect the necessary terrain data during one of the numerous passes that will be made after mainline control is established. The terrain data must be collected during the daylight hours and can be collected simultaneously with other data elements.

The terrain designation will be determined by performing a visual assessment of the terrain through which the State Route is passing and will assign the class based upon the criteria for the 3 categories: Mountainous, Rolling and Level. A terrain type will be assigned at the beginning of the route, the end of the route and all terrain changes that occur along the route. An ARM value will assigned to the beginning and end of every route as well as all subsequent terrain changes.

POLES & SUPPORTS RUN

UTILITY POLES

Definition - A support used to hold up any utility fixture occurring adjacent to a State Route.

Pole Types

- Utility
- Unknown

Collection Procedures

Location of these features will include: ARM, XYZ at both ends, whether increasing or decreasing, right / left indicator, and the offset distance to fogline. We will also be indicating whether breakaway or rigid.

ILLUMINATION

Definition - A light fixture supported by a pole that is adjacent to a State Route.

Luminaire Types

- Luminaire on Concrete Barrier (LC)
- Luminaire on Slip / Breakaway Base (LB)
- Luminaire Rigid (LR)

Collection Procedures

Location of these features will include: ARM, XYZ at both ends, whether increasing or decreasing, right / left indicator, and the offset distance to fogline. We will also be indicating whether breakaway or rigid and if mounted on a barrier.

Breakaway / Rigid Examples

Breakaway

Rigid

SIGN SUPPORT

Definition - A support used to hold up any sign occurring adjacent to or over a State Route.

Support Types

- Sign Bridge (SB)
- Cantilever Sign (SC)
- Steel Post -Multiple (SM)
- Steel Post - Single (SS)
- Wood Post - Multiple (WM)
- Wood Post - Single (WS)
- Unknown

Collection Procedures

Location of these features will include: ARM, XYZ at both ends, whether increasing or decreasing, right / left indicator, and the offset distance to fogline. We will also be indicating whether breakaway or rigid and if mounted on a barrier.

MAIL BOXES

Definition - A device used to receive mail that occurs along a State Route.

Collection Procedures

Mailboxes will be collected as a miscellaneous fixed object. Location information includes: ARM, XYZ, increasing or decreasing, right / left indicator, and offset distance to fogline.

MISCELLANEOUS ELEMENTS RUN

ROADWAY FACILITY

Definition - A place, building or shelter used or maintained by WSDOT by way of ownership or agreement that occurs adjacent to a State Route.

Types

Border Station (BS)
Ferry Terminal (FT)
Park & Ride Lot (PR)
Flyer Stop (FS)
Weigh Station (WS)
Rest Area (RA)
Toll Booth (TB)
Parking Zone (PZ)
Transit Stop (TS)
Recreation Area (RC)

Collection Procedures

We will collect data on all Roadway Facilities that fall within the collection limits of the area being inventoried. The type of Facility and location information will be collected. The ARM and coordinate values will be collected at the center, or hub of the Roadway Facility.

FENCE

Definition - A device used to minimize or prevent access to the area within WSDOT right-of-way that lies along a State Route.

Collection Procedures

We will collect data on all Fences that fall within the collection limits of the area being inventoried. The type of Fence and location information will be collected.

BUILDING

Definition - Any structure used for commercial or private use occurring along a State Route.

Collection Procedures

A single XYZ will be collected at the point closest to the highway. If the Building parallels the highway, the coordinates will be collected in the middle.

An ARM value and an offset distance will be collected at the same point where the XYZ is collected.

PTR LOCATION

Definition - A permanently located device alongside a State Route that records traffic data.

Collection Procedures

An XYZ will be collected at the cabinet. An ARM value will be collected at a right angle to the cabinet and an offset distance will be measured to the same point where the XYZ is collected.

MP MARKER

Definition - A physical, numbered sign along a State Route, which indicates an approximate logical milepost.

Collection Procedures

An ARM value will be collected at a right angle to the sign / paddle and an offset distance will be measured

MISC. FEATURE

Definition - A feature which fits no current category that appears in the median or is adjacent to a State Route.

Collection Procedures

Miscellaneous features will be collected as either a Linear, or Discrete Feature. Data will include location information and a description field.

6. VALIDATION & OFFICE PROCEDURES

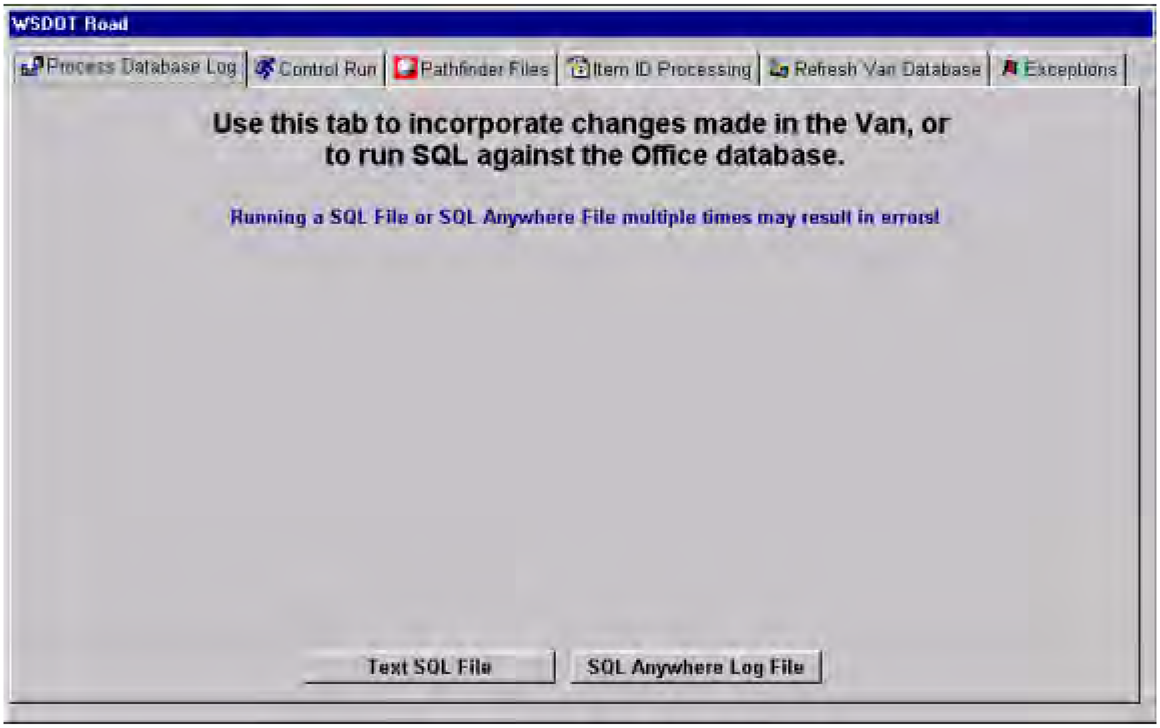
OFFICE PROCEDURES

DATA PROCESSING

Once the shuttle drive has been removed from ROADvan, it can then be brought in and plugged into the office PC for backup and processing. The first step in this procedure is to power off the office PC and remove the existing shuttle drive. Then, insert the ROADvan shuttle and reboot the PC. When you have logged onto the PC (now containing the ROADvan shuttle), create a CD backup of the shuttle drive and copy the GPS (**.SSF**) files, if any exist, from the shuttle's PF directory to the appropriate directories on the server (**I:\ROAD\DATA\DATETIME\SSF** & **I:\ROAD\DATA\DATETIME\COR**).

The **.SSF** files in the COR directory (**I:\ROAD\DATA\DATETIME\COR**) must be post processed in Pathfinder Office using the appropriate base files. This procedure will create corrected (**.COR**) GPS files. These **.COR** files must be copied to the **I:\ROAD\DATA\DATETIME\EDIT** directory on the server. Any editing to the corrected data deemed necessary should be done to the files in the edit directory (i.e. deletion of points, etc.). Once the GPS files have successfully been post processed and edited, they must be exported. This will create a **.POS** file which will be used for the merging process later.

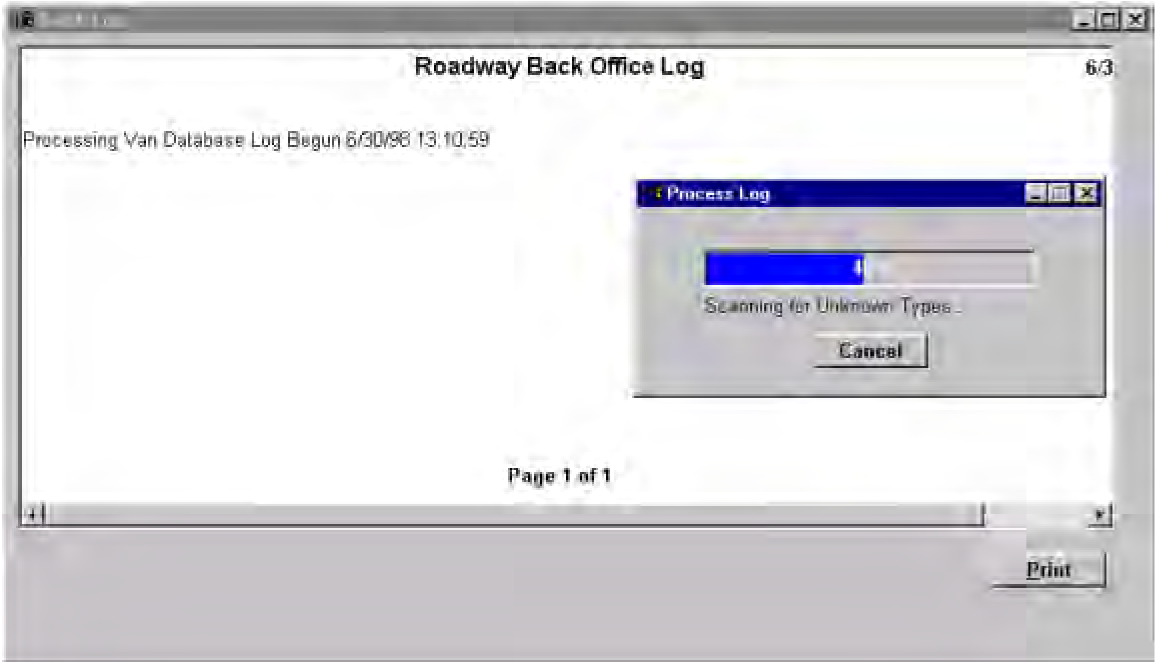
Back Office Main Screen



After performing the proper backup procedures and post processing, editing & exporting GPS data (if applicable), you are ready to start the Back Office software. Start the Back Office software by double clicking the icon on the desktop. Then log in by entering the appropriate user id & password.

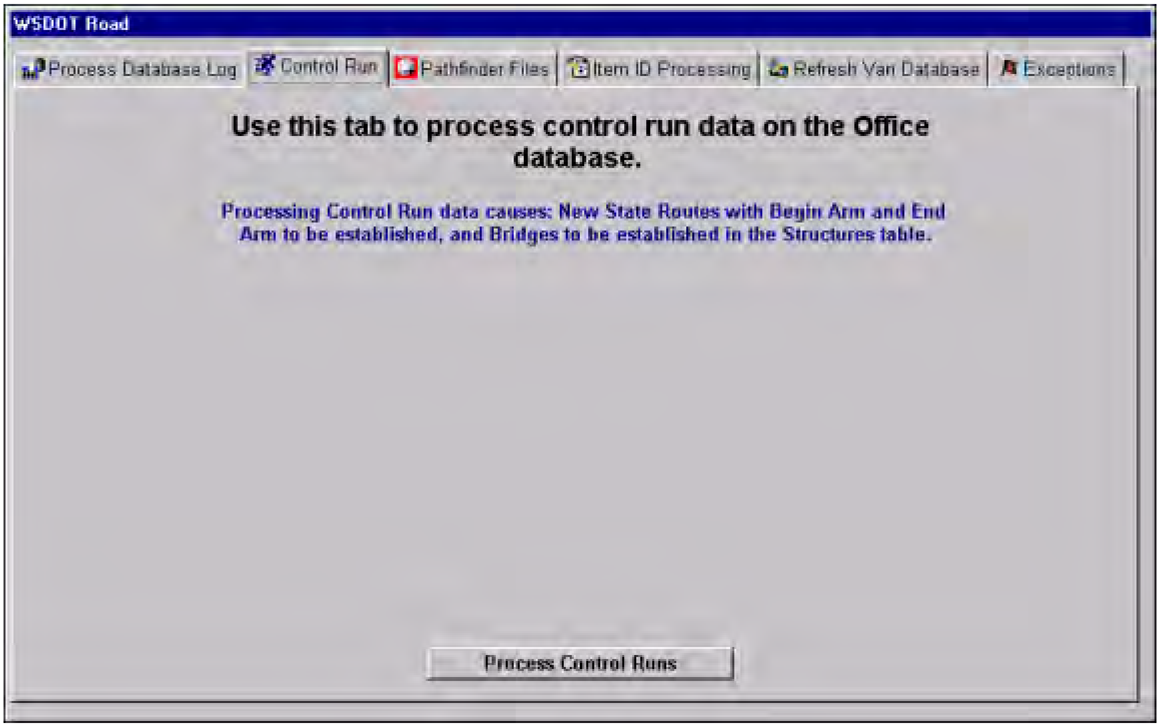
1. Once you are logged into Back Office, the "**Process Database Log**" tab should be showing (see Back Office Main Screen on previous page). Press the "**SQL Anywhere Log File**" button. During this process you will see several progress bars appear, cycle to completion & disappear while the report is generated (see below). When the Database Log is finished processing, you can use the scroll bar to view the report or print it by clicking the "**Print**" button.

Database Log Report

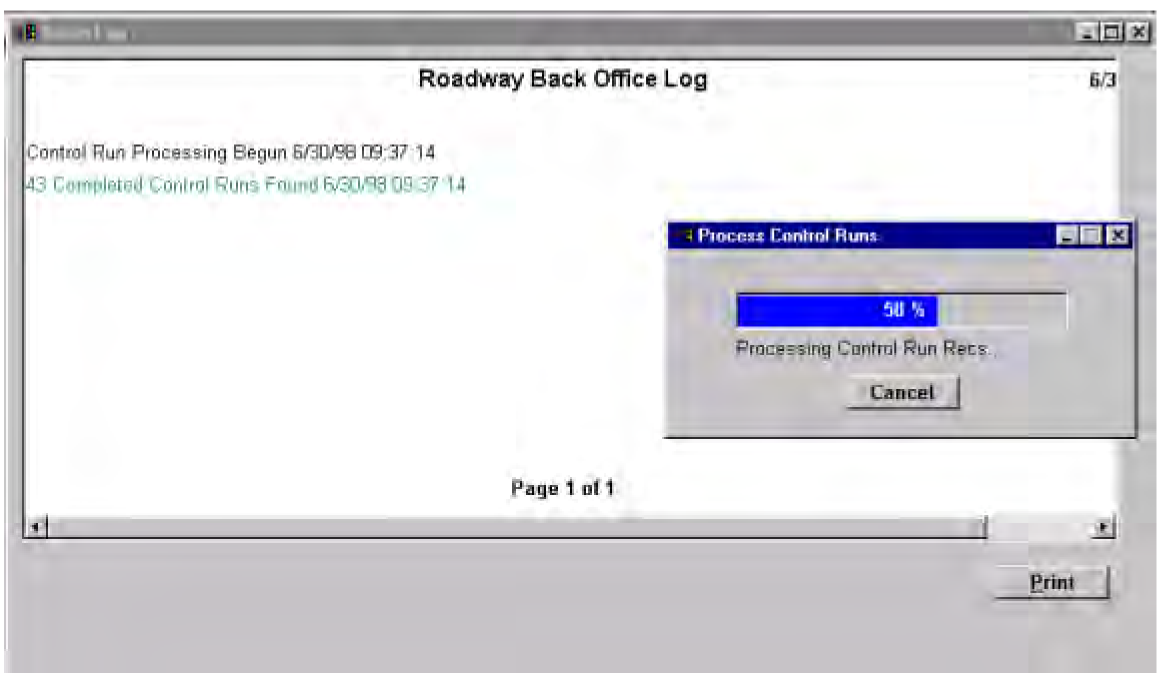


If the control run has already been processed for the route currently being updated, skip this step and proceed with step 3. To process the control run, choose the "**Control Run**" tab (see Control Run Tab next page) and press the "**Process Control Runs**" button. During this process you will see several progress bars appear, cycle to completion & disappear while the report is generated. When the process is complete, you can view the report (see Control Run Report next page) using the scroll bars or print it by pressing the "**Print**" button. Since this step is used to establish the begin & end ARM values of a route, there should not yet be any GPS data to merge. After processing the control run, go directly to step 3 to refresh the shuttle drive.

Control Run Tab

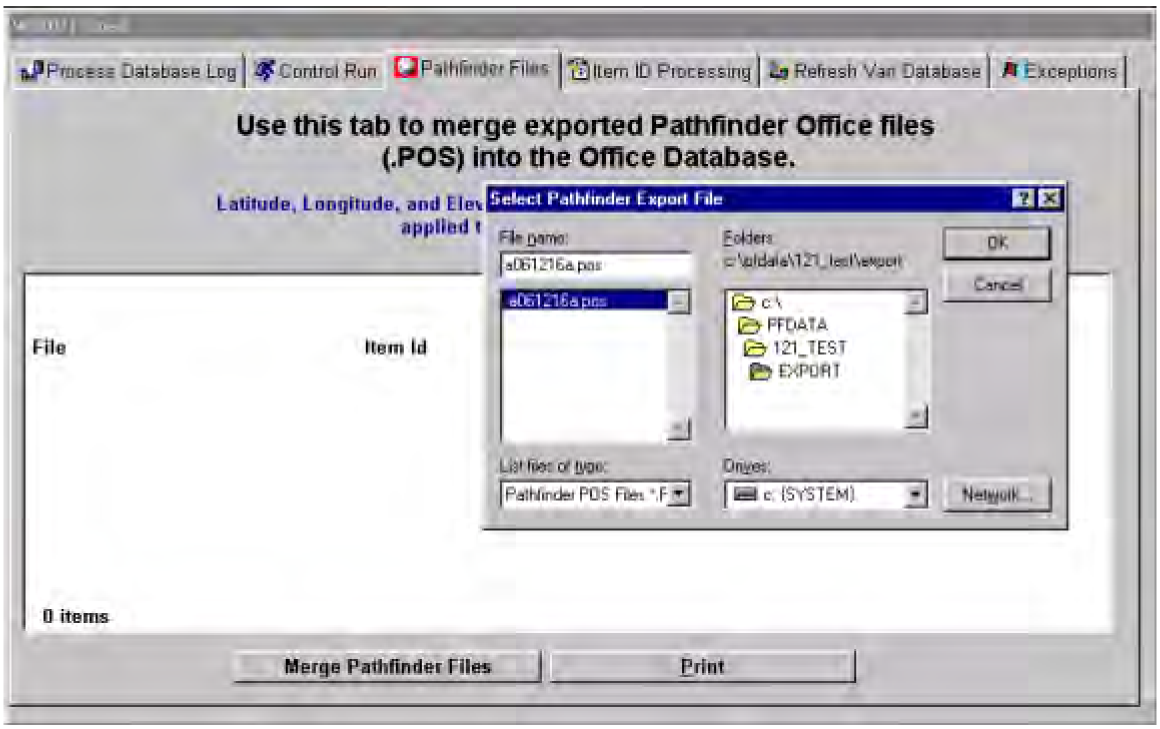


Control Run Report



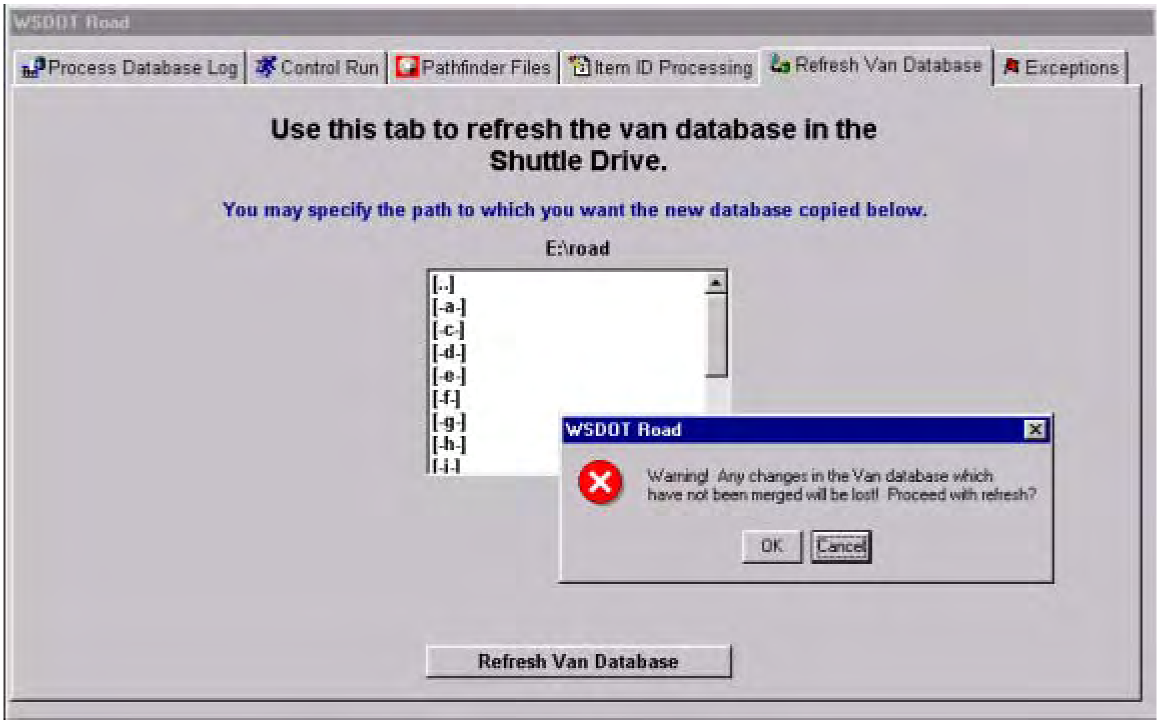
3. After properly exporting the GPS files, you can initiate the Merge process (Item ID match). Click the "**Pathfinder Files**" tab and press the "**Merge Pathfinder Files**" button. You will be prompted to select the location of the **.POS** file to be used (see Merge Report below). After selecting the appropriate **.POS** file, click the "**OK**" button. During this process you will see several progress bars appear, cycle to completion & disappear while the report is generated. When the merge is complete, you can view the report by using the scroll bar or print it by clicking the "**Print**" button.

Merge Report

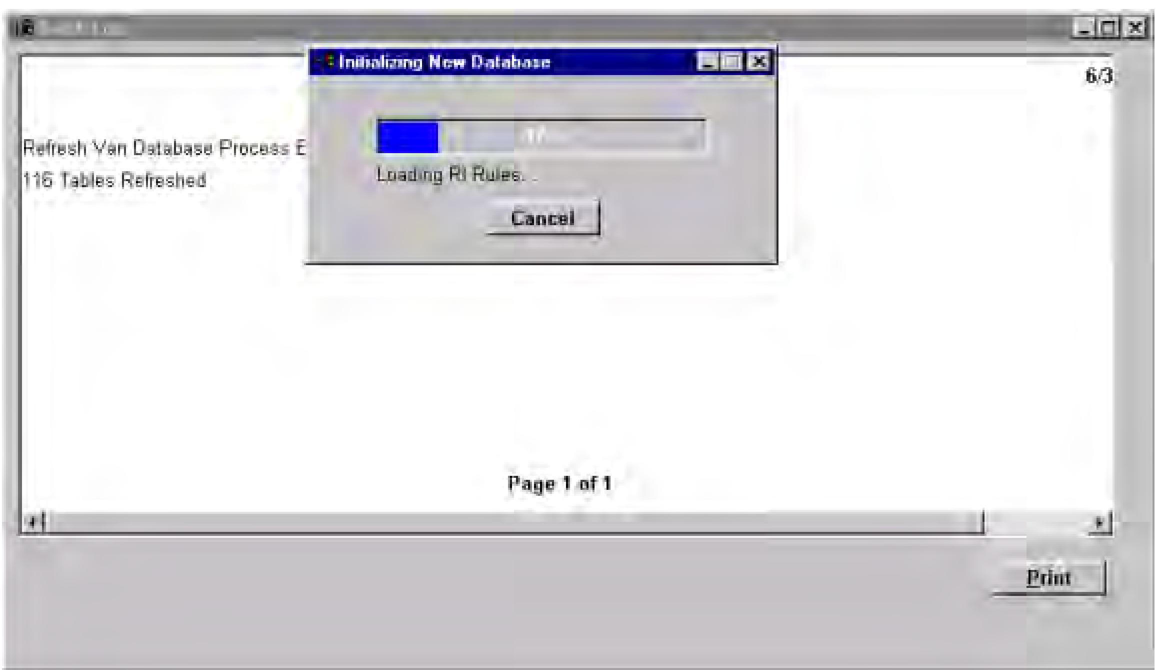


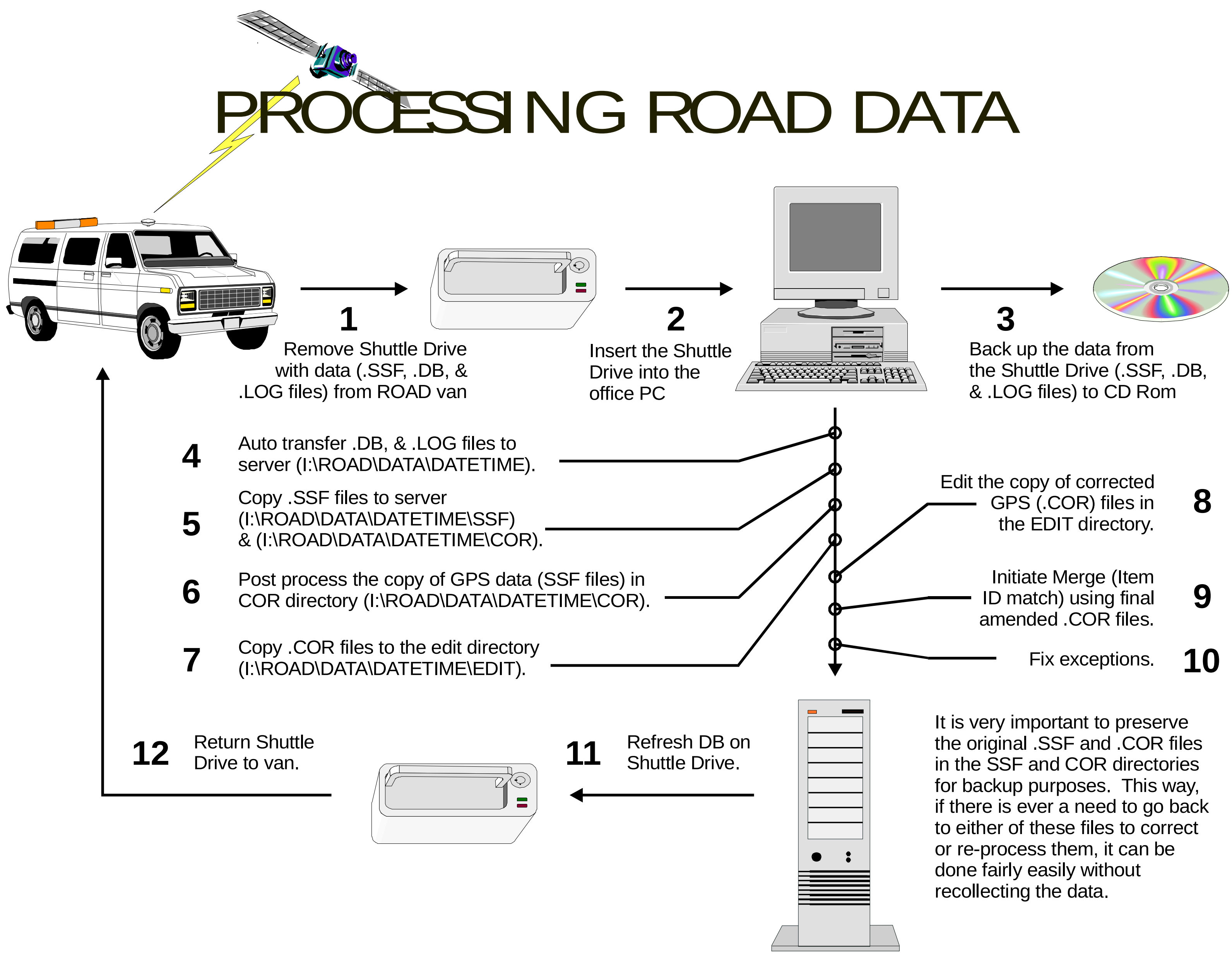
3. The shuttle drive must be refreshed before being returned to the ROADvan. This procedure copies the current data (including merged GPS data) from the server database onto the shuttle drive. Choose the "**Refresh Van Database**" tab. Using the scroll bar, scroll down the list and click the appropriate drive letter, then click on "**[road]**". The text just above the list box should now describe the correct path to the road directory on the shuttle drive (**E:\road** where E: is the drive letter for the shuttle). Now click the "**Refresh Van Database**" button. When the warning message appears, click the "**OK**" button (see Refresh Tab next page). During this process you will see several progress bars appear, cycle to completion & disappear while the report is generated (see Refresh Report next page). When the refresh is complete, you can view the report by using the scroll bar or print it by clicking the "**Print**" button. The shuttle is now ready to be taken back out to the ROADvan.

Refresh Tab



Refresh Report




PROCESSING ROAD DATA
1
Remove Shuttle Drive with data (.SSF, .DB, & .LOG files) from ROAD van
2
Insert the Shuttle Drive into the office PC
3
Back up the data from the Shuttle Drive (.SSF, .DB, & .LOG files) to CD Rom
4
Auto transfer .DB, & .LOG files to server (I:\ROAD\DATA\DATETIME).
5
Copy .SSF files to server (I:\ROAD\DATA\DATETIME\SSF) & (I:\ROAD\DATA\DATETIME\COR).
6
Post process the copy of GPS data (SSF files) in COR directory (I:\ROAD\DATA\DATETIME\COR).
7
Copy .COR files to the edit directory (I:\ROAD\DATA\DATETIME\EDIT).
8
Edit the copy of corrected GPS (.COR) files in the EDIT directory.
9
Initiate Merge (Item ID match) using final amended .COR files.
10
Fix exceptions.
It is very important to preserve the original .SSF and .COR files in the SSF and COR directories for backup purposes. This way, if there is ever a need to go back to either of these files to correct or re-process them, it can be done fairly easily without recollecting the data.
11
Refresh DB on Shuttle Drive.
12
Return Shuttle Drive to van.

DATA VALIDATION

Validation of data for this project will be perform through a series of checks and balances in the field and in the office. The following validation procedures have been established by Transportation Data Office personnel. They are based on years of experience in the field of data collection and an intimate knowledge of our state highway system.

LRS SURVEYS

Since a DMI calibration course could potentially be 50 to 100 miles away from where the data collection is taking place, it may be necessary to establish a calibration course in the vicinity of where the work is being performed.

CALIBRATION COURSE - SETUP PROCEDURES

Insuring that the DMI is as accurate as possible throughout the course of a survey will require continual calibration. In order to calibrate the DMI, and not have to travel considerable distances to a currently established calibration course, it may be necessary to setup several calibration courses within the project limits (typically the project limits will be the beginning and end of a State Route).

Measuring a Calibration Course

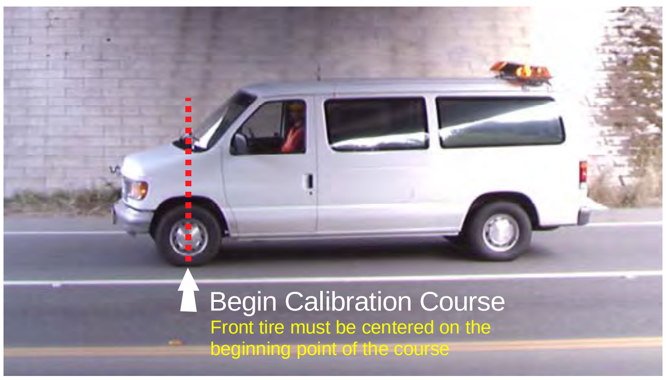
A calibration course can be established by selecting a 1 mile segment of highway that is indicative of the project terrain. When selecting the course, safety is the most important factor. The shoulder must be wide enough to accommodate the survey vehicle, allowing the crew to drive the entire mile course without crossing the “fog line” (white stripe denoting edge of travelway) into the lanes of travel.

Once the area is selected, the course can be established by using a rollatape, or “wheel” as it is commonly referred (above left). The wheel is rolled along the ground, measuring the distance covered in one foot increments.

The beginning and end points of the course must be painted on the shoulder in such a way that the driver can stop the vehicle on the mark without getting out of the vehicle (after stopping, the driver can creep forward if necessary, centering the front wheel on the mark).

DMI CALIBRATION

To insure that the DMI is performing properly and giving the operator accurate readouts, it must be calibrated periodically. **A minimum of once a week will be mandatory.**

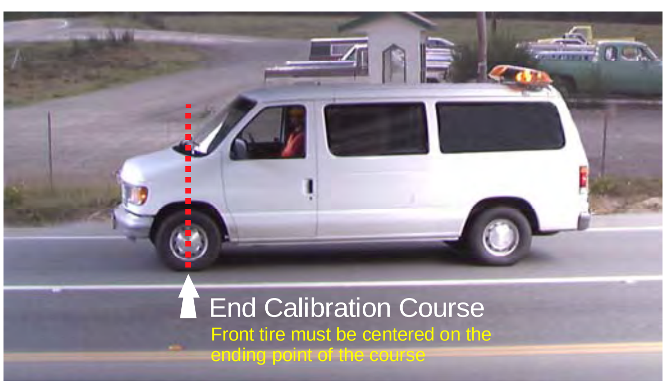


Calibration Course

The DMI must be calibrated on a designated calibration course (preferably a 1 mile course). The calibration course on I-5 just south of Olympia is an ideal example.

Before arriving at the calibration course, check the tire pressure and add air if necessary. Upon arrival, stop the vehicle with the front tire centered on the beginning point of the course (see example above).

Next, setup the DMI for calibration (refer to DMI manual) and begin driving the course. Stop the vehicle at the end of the calibration course. Align the same vehicle reference point use used at the beginning with the end reference point of the course (see below).



Once calibrated, enter the calibration number into the DMI's memory. This calibration number is for DMI/Vehicle combination you are currently using. It **will not** work for any other DMI/Vehicle combination.

GPS SURVEYS

Errors in GPS surveys are not as obvious as conventional surveys such as compass and chain surveys. That is, there is no closure formula and compass-rule balancing procedure which can detect mistakes and distribute random errors correctly throughout a survey. A validation process is necessary to insure all reasonable steps are taken to safeguard against large amounts of data being collected in error.

MONUMENTATION DATABASE

Field validation of the GPS receivers used for this project will be performed by utilizing the WSDOT Geographic Services Monument Database (located at: wsdot.wa.gov/monument/). The monument database contains a set of entities and attributes as referenced to individual geographic locations. Each individual Point has a location relative to all other points in the database as referenced to a coordinate grid. The relative location of the points as represented in this database correspond to the physical or determined locations of Survey Control Monumentation. Attribute values of each point may contain accuracy data, physical descriptions on the monuments, descriptions for retracement and recovery, horizontal and vertical reference datum's, dates of recovery, determination, origin of data values, and methods used for value determination.

The ROAD crew will continually verify the accuracy of their equipment by "checking-in" to one or more of the monuments in the vicinity of where the survey is being performed.

OFFICE VALIDATION

Further validation of the data will be performed in the office by comparing new LRS data to existing LRS data sources. In addition, GIS software will be used to inspect and post process the GPS data.

ACCURACY OF DATA

The accuracy of the GPS data is based on several factors - Selective Availability, Atmospheric Delay and Multipath Errors.

Selective Availability

Selective availability is intentional scrambling of the GPS signal that reduces autonomous positioning accuracies up to 100 meters 95% of the time. S/A is the largest source of error in the GPS system but can be corrected using differential correction techniques.

Atmospheric Delay

GPS signals bounce around when traveling through the ionosphere and troposphere. As the signal bounces, the amount of time it takes to reach the earth is altered. This can change the calculated position. Atmospheric delay is largest during the heat of the day when ionospheric activity is greatest.

It should be noted that GPS works in all weather conditions.

Multipath Errors

Multipath error is dependent on many environmental parameters. It occurs without warning and can be minor or alter your GPS position by many meters. There is currently no way to prevent multipath from occurring, however, field techniques and receiver firmware can reduce its affects. Serious multipath errors are usually recognizable and easily edited in Pathfinder Office.

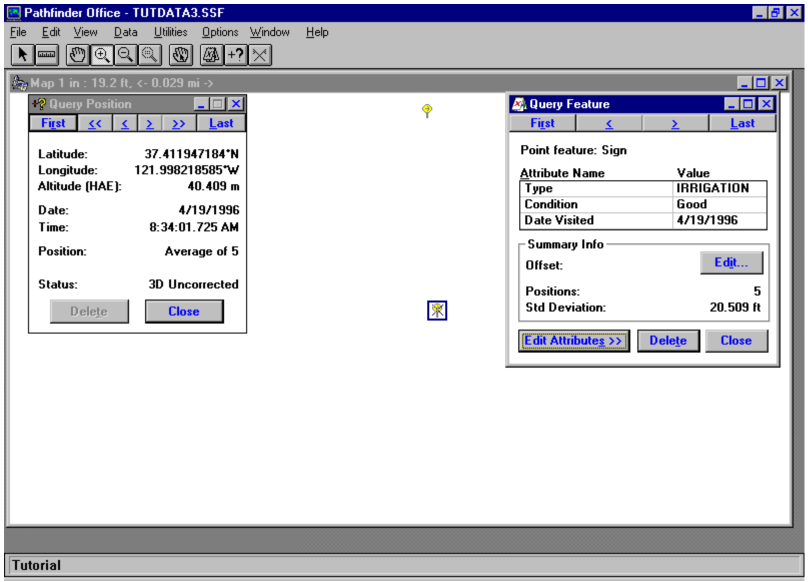
Multipath Errors are caused by the reflection of satellite signals off larger nearby objects, such as buildings, trees, cars, etc. These errors are distinguishable and correctable in Pathfinder Office.

PATHFINDER OFFICE

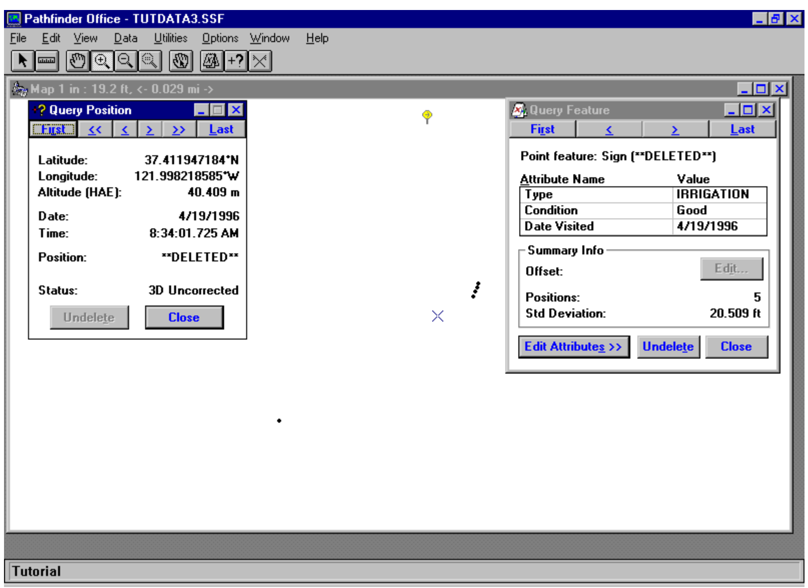
The Pathfinder Office software provides all the functionality needed to post-process, view and edit GPS data collected in the field. It also allows the exporting of data in a format suitable for merging the GPS data into the ROAD database.

Finding and Editing Multipath Errors

In Pathfinder Office, a feature (a GPS point representing an average of all the points collected at a given location) can appear to look out-of-place with the rest of the points or features (e.g., features, or points along a guardrail - an out of place feature is noticeable). Another way to tell if a feature is out-of-place is by looking at the standard deviation. If the standard deviation is larger than the allowed deviation, a multipath error may be causing the problem and should be corrected prior to merging the Item ID numbers together (see section on Data Collection).

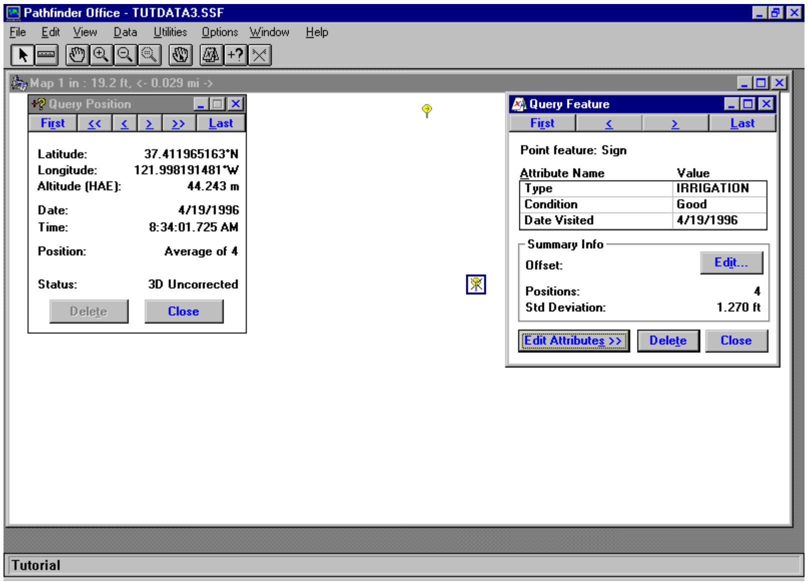


To edit the feature (eliminate multipath error), delete the feature in question (this will display all the positions that were collected and averaged to make up the feature). A series of positions can now be viewed (see below).



Multipath positions will have certain characteristics, e.g., a line of positions that look out-of-place. Deleting these multipath positions should bring the deviation to within the acceptable limits.

After the feature is “undeleted”, its placement will be adjust on the map (see below).



Post Processing

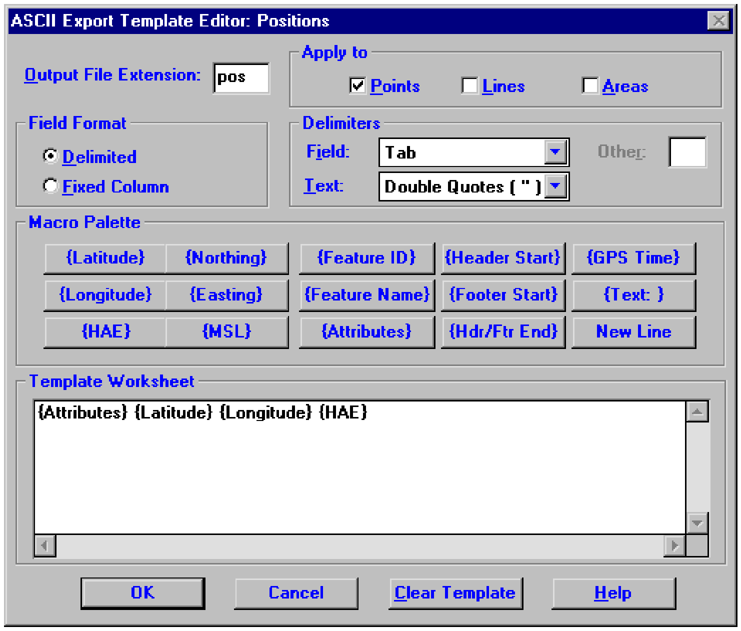
Even though we will be collecting DGPS the majority of the time, all GPS data will be Post Processed.

Base station availability for post processing can be accessed over the Internet, or by calling the Coast Guard or the community base in the vicinity .

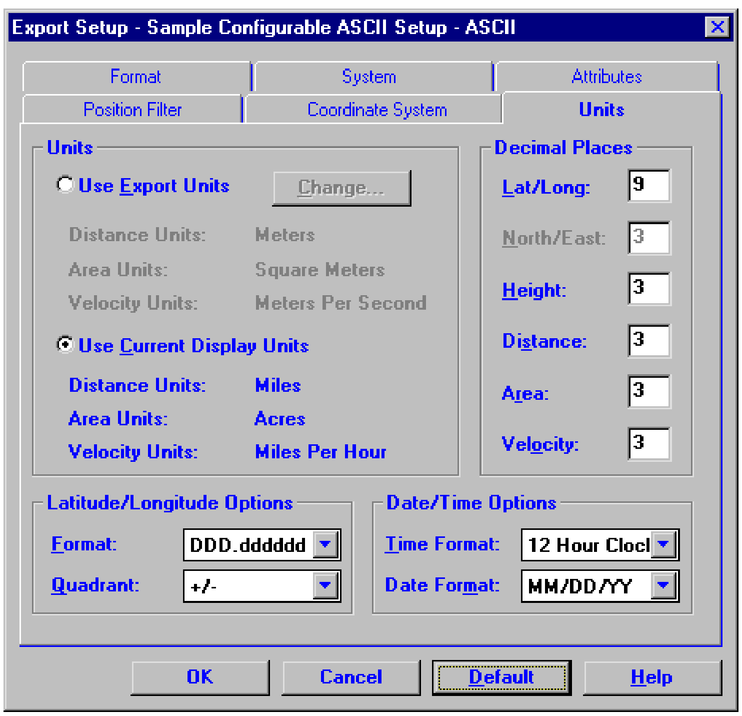
EXPORT FORMAT

The Export format used for download to Data Base purposes will be Sample Configurable ASCII Setup. Attributes (Item ID #), Latitude, Longitude, and Height above Ellipsoid (HAE) of each feature will be included in the Template Worksheet .

The following is an example of the Template Editor screen (export format).



The following is an example of the export setup screen.



GIS SOFTWARE

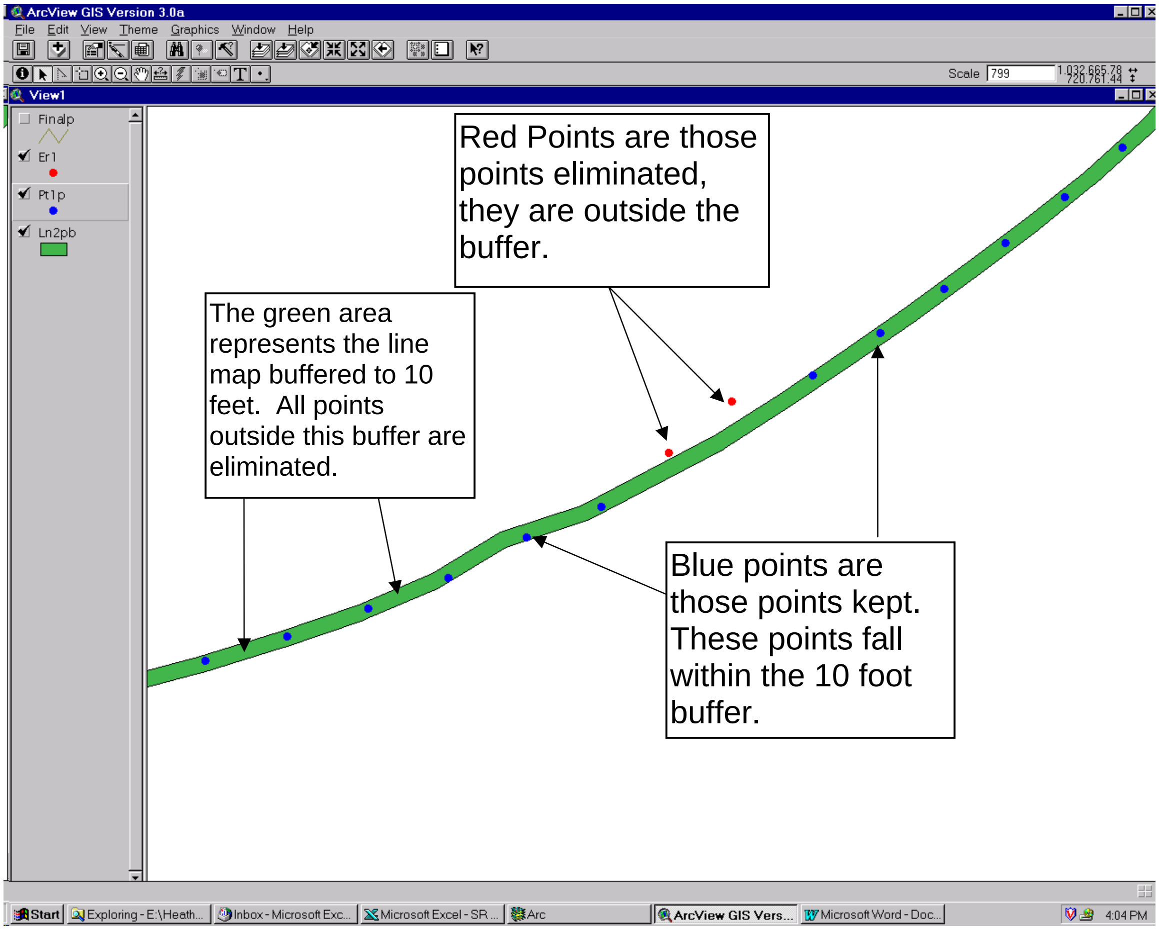
ArcView

We will be utilizing ArcView software to help facility validation of the GPS data, and to provide an additional comparative analysis tool for measuring the feasibility of collecting ARM values with GPS equipment.

The ROAD van, equipped with a GPS receiver, will drive a State Route collecting GPS points, describing its location at various intervals (see GPS Mainline Run). The GPS points will be saved in a Pathfinder Office file. When plotted the points will describe the run the truck drove (two runs will take place to insure there are no "holes" in the data). Even though most of the points plot in the proper location, several factors cause some of the points to return an erroneous location. They are: interference from trees, buildings, bridges (multipath errors) and misalignment of satellites. These erroneous points need to be eliminated from the GPS point file. A “Buffer” technique is being developed which eliminates erroneous points from the GPS Mainline Run.

We will be using ESRI’s GIS software Arc/Info and Arc Macro Language to automate the removal of erroneous points. By driving the State Route twice, two separate files of GPS points are collected. One run is used to create a point map with points representing the State Route. The second run is used to create a line map with a line representing the State Route. Both maps are in the State Plane North projection, North American Datum of 83 with feet for units. From the line map a buffer zone is created five feet on each side (10' wide). This buffer is overlaid with the point map. The points from the point map that do not fall within the boundary of the buffer are eliminated. The remaining points in the point map represent the points from one run that that fall within 5 feet of the other run.

These remaining points create a line map with a line representing the State Route. Arriving at a route length using this GPS method resulted in a route length of 59.789 miles. The Control Run established a length or ARM value of 59.795 (arrived at using a DMI) for our test route (SR-3).


ArcView GIS Version 3.0a
File Edit View Theme Graphics Window Help
Scale 799
View1
Finalp
Er1
Pt1p
Ln2pb
Red Points are those points eliminated, they are outside the buffer.
The green area represents the line map buffered to 10 feet. All points outside this buffer are eliminated.
Blue points are those points kept. These points fall within the 10 foot buffer.
Start
Exploring - E:\Heath...
Inbox - Microsoft Exc...
Microsoft Excel - SR ...
Arc
ArcView GIS Vers...
Microsoft Word - Doc...
4:04 PM

7. DATABASE CONSTRUCTION

DATA MODELING

The construction of the ROAD database began in 1997 with numerous Conceptual Data Modeling sessions. These sessions, along with brainstorming meetings; research on equipment needs, functionality and availability; field tests using mock data collection software; and training, took place throughout 1997 to current.

Key Structure

The Primary Key is comprised of — State Route, Related Roadway Type, Related Roadway Qualifier, and an Increasing / Decreasing Indicator. There are many considerations when constructing a database, the key structure is paramount.   For example: If any Class Areas, or anything jurisdictional (e.g., County, City, Region, etc.) is a part of the key, it will lead to considerable data collection problems. One reason for this is that most jurisdictional areas are not marked in the field, making difficult, at best, to know where one jurisdiction ends, and another begins**. If it is in the key, it must be collected**. When constructing a database (for databases that will need to link to TARIS), we recommend that it be modeled with the help of WSDOT's Management Information Services.

Lastly, it is recognized that the current database, software and procedures established in this manual will continue to evolve. A new version of this manual will be generated upon completion of the pilot project. Included will be any changes to the database, software and/or procedures.

Road Application Developer's Guide

Prepared By Jeff Scott
June 25, 1998

Purpose

The purpose of this document is to provide programmers with enough information on the Road system software to maintain and enhance the system as necessary. Familiarity with the Road data model, as well as Powerbuilder 5.0, Powerbuilder Foundation Class libraries, MSComm32.ocx, and FUNCKY for Powerbuilder are assumed.

Scope

This document provides functional descriptions of the system. In some cases, code snippets from the Road system are used for illustration. Details of the objects and coding techniques are found in the Road System Object Reference.

Description

The Road application is comprised of two separate applications: 1) software which is used in the van to collect inventory data, and 2) software used to process that data in the office. While the van software is primarily used in the field for data collection, it may also be used in the office to review and modify data in the system.

Both software components are written in Powerbuilder 5.0.03 using the Powerbuilder Foundation Class libraries (PFC). Refer to Powersoft Online Books for details of the PFC. Other elements of the software include the MSComm32.ocx control for serial port communications with a DMI, Funcky for Powerbuilder, SQL Anywhere 5.5, and for LAN storage of the data and access from the office, Microsoft SQL Server 6.5. Specifics of these products can be found their respective product documentation.

Disclaimers

Due to time constraints, the system, including the framework, were not fully developed. Areas which were not completed are as follows.

Framework Issues

Some code implemented on specific windows should have been migrated to ancestor objects. Most notably, code in the OPEN event of linear and discrete features should have been moved. The UE_SETKEY event contains similar code for opening a window in "New Mode", and that code was implemented in the ancestor.

Common edits, such as ARM value checks, were implemented in the ancestor code. Many of these edits were implemented in the ancestor to save time, and such edits do not apply to all descendents. These application specific edits should be migrated to specific windows.

A PRINT button is present on virtually every window. This functionality implements the standard PFC print capability, which allows for printing of the current datawindow. This functionality should be extended to allow printing of all information on the window, i.e. all datawindows on the window.

Edits

While many edits were implemented at the ancestor level, rules to ensure ARM values within the range of all parent objects were not implemented. An example is that Begin and End ARMs entered for a guardrail, as well as the ARM values for guardrail points, are verified to be within the ARM of the State Route. But ARM values entered for points on a guardrail are not currently verified to be within the Begin and End ARM of the guardrail.

Framework Components

The primary components of the Road Van framework are listed here. They form the infrastructure used in the Road Van software. See the Road System Object Reference for specifics on these objects.

W_ROADFRAME – This is the application MDI frame window. It utilizes M_ROADFRAME as its menu. Sheet windows within the system do not use menus of their own.

W_ROADSHEET – This is the primary application window ancestor. It contains a datawindow control, dw_data, on which most processing is based. The window also contains common edits and DMI communication logic. This window also controls deletes against its datawindow, dw_data. When rows are deleted via the pfc_delete( ) event, the PFC multitable service is disabled. In disabling this service, it is required that the DBMS implements cascaded deletes so that all dependent records are cleared. Thus, it is essential that any maintenance to the databases that may require dropping and re-creating tables, re-establish cascaded deletes via triggers (in the case of MS SQLServer) or via declarative referential integrity (in the case of SQLAnywhere).

W_DISCRETE_FEATURE – This is the primary ancestor window for Discrete Features. It contains edits common to Discrete Features, as well as record key management logic.

W_LINEAR_FEATURE– This is the primary ancestor window for Linear Features. It contains edits common to Linear Features, as well as record key management logic.

W_LINEAR_WITH_CHILD – This is a special ancestor window used to implement linear features with 2 multiple dependent tables, as in the case of guardrails and sidewalks.

W_DISTANCE – This window is used to implement all dependent entities which require a list style presentation. Typically, XYZ offset values are implemented using this window, however, any list style dependent entity may use this window.

S_KEYS – This structure is used by W_LINEAR_FEATURE and W_DISCRETE_FEATURE to pass keys, the window title, and the datawindow object to the W_DISTANCE window.

M_ROAD – This is the primary application ancestor menu, on which all code and menu items reside.

M_ROADFRAME – This is the Frame window menu, descendant of M_ROAD.

W_PALETTE – This is an ancestor window used to support the opening of windows via buttons, grouped by function. The group, the individual functions, and the code for opening the windows must be implemented on the M_ROAD menu. Each descendant window must then establish a pointer to the menu. When opened, the window then creates a button for each visible enabled menu item. Each button is of type U_CB_PALETTE, and, when clicked, triggers the related menu clicked event.

U_DMI – This is the ancestor DMI object. It is designed to serve as a repository of constants and stub functions needed to support any type of DMI. It is implemented as a custom visual object which offers registration and notification services. Specific registration, communication, and notification functionality must be implemented in descendants.

U_DMI_RAC200 – This object supports the JAYMAR RAC200 DMI. Descendant of U_DMI, it implements the specific constants, interfaces, registration and notification services supporting communications with the RAC200 DMI. It employs the Microsoft MSCOMM32.ocx as a serial port interface object. W_ROADSHEET contains code to register the window with the DMI object, so that the window may be notified of incomming data. Thus, any descendant of W_ROADSHEET supports requesting and placing DMI data onto dw_data with no descendant code required.

N_CST_ROAD_SQL – This NVO contains all embedded SQL used within the system.

U_CB_ADD – An extended PFE U_CB used to add a new record to the current datawindow.

U_CB_CLOSE – An extended PFE U_CB use to close the current window.

U_CB_DELETE – An extended PFE U_CB used to delete the current row in the current datawindow.

U_CB_INSERT – An extended PFE U_CB used to insert a new row in the current datawindow.

U_CB_OK – An extended PFE U_CB used to initiate default processing on the window.

U_CB_PRINT – An extended PFE U_CB used to print the current datawindow.

U_CB_RETRIEVE – An extended PFE U_CB used to initiate a retrieve on the primary datawindow.

U_CB_PALETTE – An extended PFC U_CB used on the W_PALETTE window. Triggers a menu event when clicked.

PFE Extension Classes

In general, the Road Van software uses a window infrastructure (frame, sheets, and menu structures) identical to the Quickstart sample application installed with Powerbuilder. Refer to the Powerbuilder On-Line Books for details on the Quickstart application.

The primary change to the PFE extension libraries is in the n_cst_logon object, of_logon( ) function. This function is modified to allow three tries on the logon window. An instance variable is declared to count the number of tries: int ii_tries

For each execution of pfc_default, ii_tries is incremented, and if the incremented value equals three, the window is exitted:

```
ii_tries++
If ii_tries = 3 or inv_logonattrib.ii_rc =1 Then
    CloseWithReturn (this, inv_logonattrib)
Else
    sle_password.setfocus()
End If
```

All controls in the PFEMAIN library were modified to contain an instance variable IB_CHANGED which is set to true on the control's primary event, such as modified for singlelineedit controls. PFC and PFE library components are not documented in the Road System Object Reference.

Road Van Software

The Road Van software is an MDI application, which employs an application framework built upon the PFC. Framework components handle serial port communications with the DMI, as well as much of the editing and record key management for the descendent components. Common edits are also handled in the framework components, such as ARM values within the range of beginning ARM and Ending ARM for a State Route. The framework is based on models, which directly supports independent entities, master detail on a single window, master detail on two windows, and various other master detail combinations. Some of the uses for the Master Detail configurations are Linear Features and their XYZ Offset records (shown on two windows), and Barriers for which a specific type (Guardrail) requires a dependent table entry.

The vast majority of the primary data entry datawindows display only a single record. Lists and grid types are used mainly for record selection and only occasionally for data entry. Multiple page form datawindows are not used, and none of the other datawindow presentation styles are employed.

The system is tightly coupled to the data model. Key structures in the data model are implemented in the ancestors and the application hierarchy. Using this technique, new application windows can be easily added. The addition of new Linear and Discrete feature windows would require no new code to implement the infrastructure (master/detail windows) and key management, unless extra key values are needed.

All selection windows are implemented via the standard PFC selection service. Distance windows all use a common w_distance window, which supports any list style detail window.

Adding New Windows

In order to add new windows to the system, the developer must first determine where in the system the new window best fits. This determined by examining the key structure for the new entity. Refer to the Road System Data Model for Linear and Discrete Feature

If the entity is a new Discrete Feature, or if it contains the standard State Route key elements (SR_NUM, RRT_CODE, RRQ, and INCR_DECR_IND) AND a single ARM value, it is most easily implemented as a descendant of W_DISCRETE_FEATURE. By using W_DISCRETE_FEATURE as the ancestor, all standard Discrete Feature keys are managed by the ancestor window. Code only needs to be added to support additional key columns. If the new feature uses only a subset of the standard Discrete Features key columns, then copying and modifying the OPEN script from another Discrete Feature window provides the simplest method of implementing the differences. The UE_SETKEY event should be overridden and modified to implement differences in the entity keys.

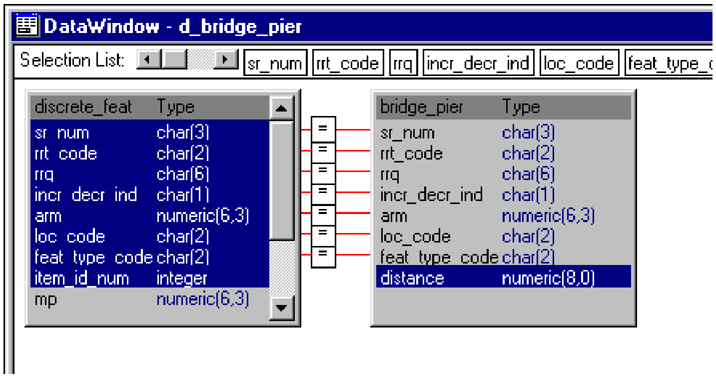
If the entity is a new Linear Feature, or if it contains the standard State Route key elements (SR_NUM, RRT_CODE, RRQ, and INCR_DECR_IND) AND Begin ARM and an End ARM values, it is most easily implemented as a descendant of W_LINEAR_FEATURE. By using W_LINEAR_FEATURE as the ancestor, all standard Linear Feature keys are managed by the ancestor window. Code only needs to be added to support additional key columns. In addition, the infrastructure supporting a separate XYZ offset window is already in place. If the new feature uses only a subset of the standard Linear Features key columns, then copying and modifying the OPEN script from another Linear Feature window provides the simplest method of implementing the differences. The UE_SETKEY event should be overridden and modified to implement differences in the entity keys.

How to use the W_DISCRETE_FEATURE and W_LINEAR_FEATURE windows

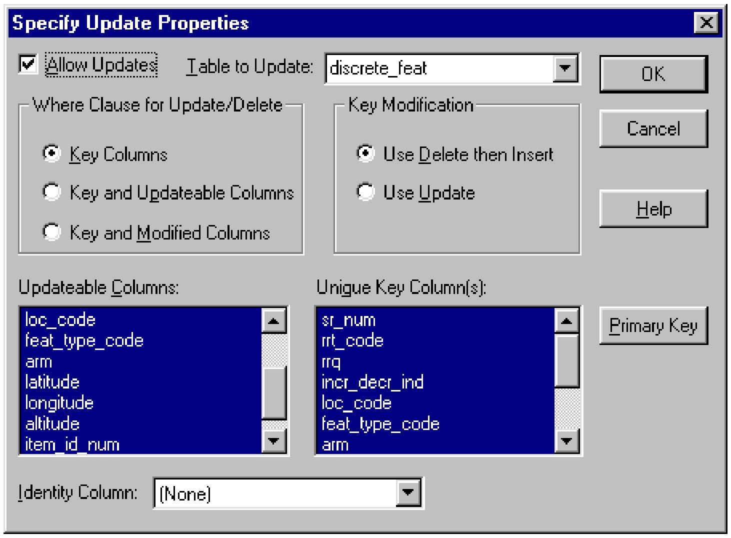
This section describes the use of the ancestor windows W_DISCRETE_FEATURE and W_LINEAR_FEATURE. The most effective means of illustrating the uses are by examining existing descendants which vary in the usage of the ancestor code. Required code is noted. Four case studies are presented here, representing examples of how the framework windows may be used.

Case 1 – W_Bridge_Pier

First, the form style d_bridge_pier datawindow was created. It’s select statement contains the key columns from the DISCRETE_FEAT table, and the remaining elements from the BRIDGE_PIER table. The tables are joined on the key columns:



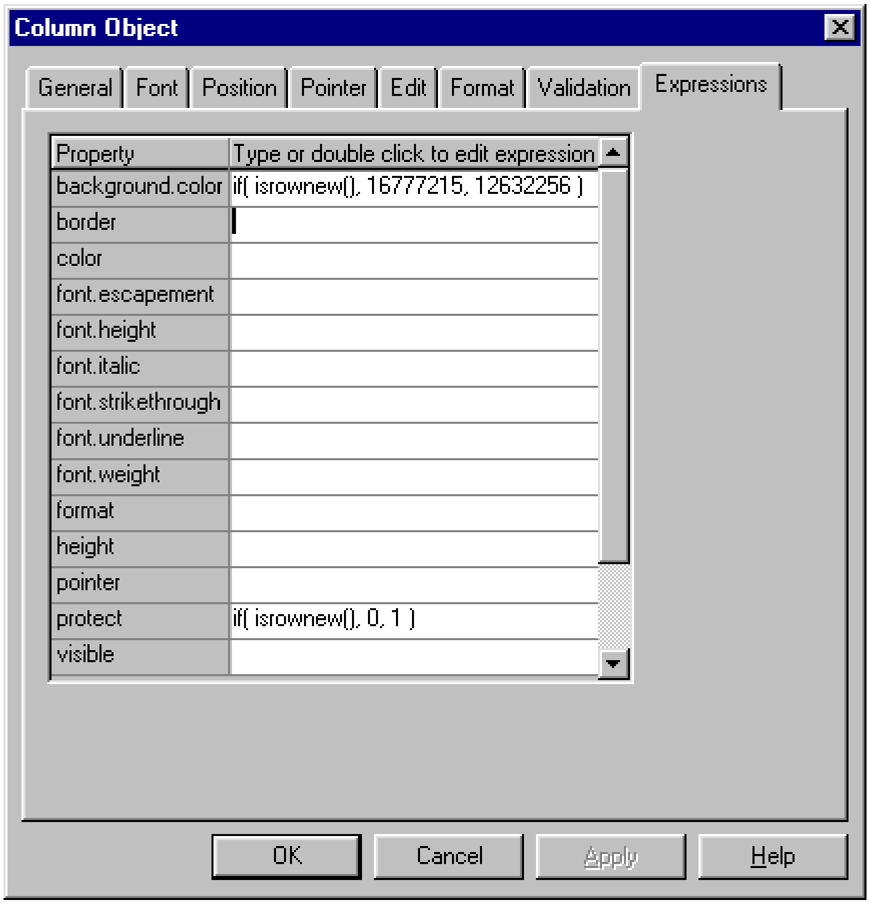
The update properties for the datawindow are specified such that the table to update is DISCRETE_FEAT. This allows the multitable service to be disabled in the PFC_DELETE( ) event, and for the delete to be cascaded by the DBMS:



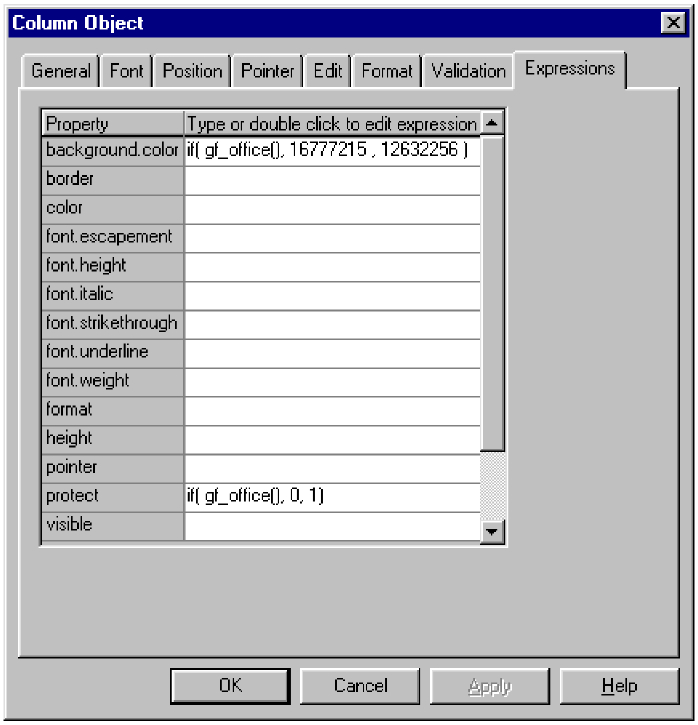
The where clause for the datawindow contains arguments for the key columns (SQL converted to syntax for illustration purposes):

```
SELECT "discrete_feat"."sr_num",
       "discrete_feat"."rrt_code",
       "discrete_feat"."rrq",
       "discrete_feat"."incr_decr_ind",
       "discrete_feat"."loc_code",
       "discrete_feat"."feat_type_code",
       "discrete_feat"."arm",
       "discrete_feat"."latitude",
       "discrete_feat"."longitude",
       "discrete_feat"."altitude",
       "discrete_feat"."item_id_num",
       "bridge_pier"."distance"
  FROM "discrete_feat",
       "bridge_pier"
 WHERE ( "bridge_pier"."sr_num" = "discrete_feat"."sr_num" ) and
       ( "bridge_pier"."rrt_code" = "discrete_feat"."rrt_code" ) and
       ( "bridge_pier"."rrq" = "discrete_feat"."rrq" ) and
       ( "bridge_pier"."incr_decr_ind" = "discrete_feat"."incr_decr_ind" ) and
       ( "bridge_pier"."arm" = "discrete_feat"."arm" ) and
       ( "bridge_pier"."loc_code" = "discrete_feat"."loc_code" ) and
       ( "bridge_pier"."feat_type_code" = "discrete_feat"."feat_type_code" ) and
       ( discrete_feat.sr_num = :sr_num ) AND
       ( discrete_feat.rrt_code = :rrt_code ) AND
       ( discrete_feat.rrq = :rrq ) AND
       ( discrete_feat.incr_decr_ind = :incr_decr_ind ) AND
       ( discrete_feat.loc_code = :loc_code ) AND
       ( discrete_feat.feat_type_code = 'BP' ) AND
       discrete_feat.arm = :arm
```

Key columns on the datawindow are given expressions that set the column background to gray and protect the column if the row is new:



Altitude, Latitude, and Longitude (called XYZ data) columns may not be modified unless in the office. Thus, their backgrounds are set to gray and protected if the gf_office( ) function returns a TRUE, indicating that the software is being executed in the office:



The next step was to create the d_bridge_pier_list datawindow for use as a selection list. It is a tabular datawindow whose selection list is simliar to the d_bridge_pier datawindow above. The where clause uses arguments for key columns, as well as additional arguments which allow selective use of the key arguments:

```
SELECT …
FROM "discrete_feat",    "bridge_pier"
  WHERE ( "bridge_pier"."sr_num" = "discrete_feat"."sr_num" ) and
      ( "bridge_pier"."rrt_code" = "discrete_feat"."rrt_code" ) and
      ( "bridge_pier"."rrq" = "discrete_feat"."rrq" ) and
      ( "bridge_pier"."incr_decr_ind" = "discrete_feat"."incr_decr_ind" ) and
      ( "bridge_pier"."arm" = "discrete_feat"."arm" ) and
      ( "bridge_pier"."loc_code" = "discrete_feat"."loc_code" ) and
      ( "bridge_pier"."feat_type_code" = "discrete_feat"."feat_type_code" ) and
      (( discrete_feat.sr_num = :sr_num ) OR
      ( :use_sr_num = 'N' )) AND
      (( discrete_feat.rrt_code = :rrt_code ) OR
      ( :use_rrt_code = 'N' )) AND
      (( discrete_feat.rrq = :rrq ) OR
      ( :use_rrq = 'N' )) AND
      (( discrete_feat.incr_decr_ind = :incr_decr_ind ) OR
      ( :use_incr_decr_ind = 'N' )) AND
      (( discrete_feat.loc_code = :loc_code) OR
      ( :use_loc_code = 'N'  )) AND
       ( discrete_feat.feat_type_code = 'BP' )
```

Note that if any of the “use_xxx” arguments is set to “N”, that particular key argument is effectively not used as where criteria. In all of the discrete and linear feature windows, either all or none of the keys are used, based on whether the defaults window is open or not. For example, if the defaults window is open, the default values for SR_NUM, RRT_CODE, RRQ, INCR_DECR_IND, and LOC_CODE are passed to the retrieve statement for d_bridge_pier_list, along with 'Y' arguments indicating that the values are to be used. If the defaults window is closed, the args are passed with 'N's , indicating that the defaults are not to be used, and the list of bridge piers lists all. See the code example in the Open( ) Event section below.

W_BRIDGE_PIER is inherited from W_DISCRETE_FEATURE As such, it inherits edits from W_DISCRETE_FEATURE and W_ROADSHEET. See the Road System Object Reference for details on these edits.

The following events represent the minimum code required to implement the window.

Open() Event

The open event establishes whether or not the window is opening in the "New Mode", the window title, and whether or not to use defaults based on the w_defaults window being open or not.

```
Any          la_values[], la_args[]
String  ls_col[]  = { "sr_num", "rrt_code", "rrq", "incr_decr_ind", "arm", "loc_code"}
String  ls_args[] = { "","","","","","Y","Y","Y","Y","Y" }
String  ls_empty
String  ls_all[] = { "","","","","","N","N","N","N","N" }
n_cst_selectionattrib lnv_attrib

// If NEW, set title only
If Message.stringparm = "N" Then
    Title  = gnv_app.is_title + " - New Bridge Pier"
Else
    Title  = gnv_app.is_title + " - Bridge Pier"

    // Get current defaults into ls_args array
    gnv_app.inv_defaults.of_get_defaults( ls_empty, ls_args[1], ls_args[2], ls_args[3], ls_args[4], ls_args[5] )

    // If w_defaults is open, use defaults, else dont
    If IsValid ( w_roadframe.of_getdefaultswindow( )) Then
        // use defaults
        la_args = ls_args
    Else
        // ignore defaults
        la_args = ls_all
    End If

    // open selection window using args, returning selected values in ls_col[]
    gnv_app.inv_selection.of_Open("d_bridge_pier_list", la_values, SQLCA, ls_col, la_args[], "Select a
Bridge Pier")
    lnv_attrib = Message.powerobjectparm

    // Close and return if they cancelled, else use the returned values
    If UpperBound( lnv_attrib.ia_returnval ) = 0 Then
        ib_disableclosequery = true
        dw_data.of_setlinkage ( False )
        Close( This )
        Return 1
    Else
        is_sr_num       = String( la_values[1] )
        is_rrt_code     = String( la_values[2] )
        is_rrq          = String( la_values[3] )
        is_incr_decr_ind = String( la_values[4] )
```

```
        id_arm        = dec ( la_values[5] )
        is_loc_code     = String( la_values[6] )

        // Force a retrieve
        IF dw_data.inv_linkage.of_Retrieve() = -1 THEN
            gnv_app.inv_error.of_message( "pfc_retrieveerror" )
        End If
    End If
End If
```

Pfc_new( ) Event

This event is used as a pass thru to the window frame.

```
gnv_app.of_getframe().event pfc_new()
```

ue_set_distance_keys()

This event is not used by discrete features.

dw_data.Constructor( ) Event

This event establishes the PFC multitable service. First , key and updatable column arrays are initialized:

```
String ls_discrete_feat_keycols[ ] = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "arm", &
                                      "loc_code","feat_type_code"}
String ls_discrete_feat_updcols[ ] = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "arm", &
                                      "loc_code","feat_type_code", &
                                      "item_id_num", "altitude", "latitude", "longitude" }
String ls_bridge_pier_updcols[ ]   = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "arm", &
                                      "loc_code","feat_type_code", "distance"}
String ls_bridge_pier_keycols[ ]   = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "arm", &
                                      "loc_code","feat_type_code"}
```

Then the multitable service is enabled, specifying update columns and key columns:

```
dw_data.of_setmultitable(true)
dw_data.inv_multitable.of_AddToUpdate  &
    ("discrete_feat", ls_discrete_feat_keycols, ls_discrete_feat_updcols, true, 0)
dw_data.inv_multitable.of_AddToUpdate  &
    ("bridge_pier", ls_bridge_pier_keycols, ls_bridge_pier_updcols, true, 0)
```

All discrete and linear features should contain similar code to allow PFC to update parent as well as dependent tables.

dw_data.pfc_retrieve( ) Event

The pfc_retrieve( ) event on dw_data retrieves data based on the keys, established in the open event:

```
Long  ll_rtn

ll_rtn = dw_data.Retrieve( is_sr_num , &
                           is_rrt_code , &
                           is_rrq, &
```

```
                                    is_incr_decr_ind, &
                                      id_arm, &
                                      is_loc_code)

    Return ll_rtn
```

Case 2 – W_Ditch

W_Ditch is inherited from W_LINEAR_FEATURE. The primary differences between windows inherited from W_LINEAR_FEATURE and those inherited from W_DISCRETE_FEATURE are that linear features have Begin_Arm and End_Arm columns as keys, and XYZ data are implemented in separate tables. Thus, features implemented using the W_LINEAR_FEATURE ancestor have a button which opens an instance of W_DISTANCE for entry of this XYZ data. Thus the ue_set_distance_keys( ) event is used to pass key information to the W_DISTANCE window on open.

D_ditch and d_ditch_list are created in a similar fashion as described in the Bridge Pier example.

Open( ) Event

This event is similar to the event described in the Bridge Pier example.

```
Any          la_values[], la_args[]
// dont use arm in key columns
String  ls_col[]  = { "sr_num", "rrt_code", "rrq", "incr_decr_ind", "begin_arm", "end_arm", "loc_code"}
String   ls_args[] = { "","","","","","Y","Y","Y","Y","Y" }
String   ls_empty
String   ls_all[] = { "","","","","","N","N","N","N","N" }
n_cst_selectionattrib lnv_attrib

is_distance_dwo = "d_ditch_distance"

If Message.stringparm = "N" Then
    Title  = gnv_app.is_title + " - New Ditch"
Else
    Title  = gnv_app.is_title + " - Ditch"

    gnv_app.inv_defaults.of_get_defaults( ls_empty, ls_args[1], ls_args[2], ls_args[3], ls_args[4], ls_args[5] )

    If IsValid ( w_roadframe.of_getdefaultswindow( )) Then
        la_args = ls_args
    Else
        la_args = ls_all
    End If

    gnv_app.inv_selection.of_Open("d_ditch_list", la_values, SQLCA, ls_col, la_args[], "Select a Ditch")
    lnv_attrib = Message.powerobjectparm

    If UpperBound( lnv_attrib.ia_returnval ) = 0 Then
        ib_disableclosequery = true
        dw_data.of_setlinkage ( False )
        Close( This )
        Return 1
    Else
        is_sr_num        = String( la_values[1] )
        is_rrt_code      = String( la_values[2] )
        is_rrq           = String( la_values[3] )
        is_incr_decr_ind = String( la_values[4] )
        id_begin_arm     = dec ( la_values[5] )
        id_end_arm       = dec ( la_values[6] )
```

```
        is_loc_code      = String( la_values[7] )

        IF dw_data.inv_linkage.of_Retrieve() = -1 THEN
            gnv_app.inv_error.of_message( "pfc_retrieveerror" )
        End If
    End If
End If
```

Pfc_new( ) Event

This event is used as a pass thru to the window frame.

```
    gnv_app.of_getframe().event pfc_new()
```

Ue_set_distance_keys ( ) Event

This event is used to initialize istr_keys for the distance window. It passes key column names, as well as their values, the W_DISTANCE window title, and the datawindow object for dw_data on W_DISTANCE. Note that the ancestor code handles SR_NUM, RRT_CODE, RRQ, and INCR_DECR_IND columns. BEGIN_ARM, END_ARM, and LOC_CODE are handled in this descendant.

```
        long  ll_row
        istr_keys.s_dwo   = is_distance_dwo

        // set the key names and values
        istr_keys.s_key[5] = "begin_arm"
        istr_keys.s_key[6] = "end_arm"
        istr_keys.s_key[7] = "loc_code"

        ll_row = dw_data.getrow()
        If ll_row <= 0 Then ll_row = 1

        istr_keys.a_value[5] = dw_data.getitemdecimal( ll_row, "begin_arm" )
        istr_keys.a_value[6] = dw_data.getitemdecimal( ll_row, "end_arm" )
        istr_keys.a_value[7] = dw_data.getitemstring( ll_row, "loc_code" )

        istr_keys.s_title = gnv_app.is_title + " - Ditch, Arm: " + string( istr_keys.a_value[5] )
```

dw_data.Constructor( ) Event

This event establishes the PFC multitable service, similar to the preceeding Bridge Pier example.

```
    String  ls_linear_feat_keycols[ ] = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "begin_arm", &
                                          "end_arm", "loc_code","feat_type_code" }
    String  ls_linear_feat_updcols[ ] = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "begin_arm", &
                                          "end_arm", "loc_code","feat_type_code" }
    String  ls_ditch_updcols[ ]    = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "begin_arm", &
                                          "end_arm", "loc_code","feat_type_code",
    "ditch_type_code", &
                                          "non_transvers_ind"}
    String  ls_ditch_keycols[ ]    = {"sr_num", "rrt_code", "rrq", "incr_decr_ind", "begin_arm", &
                                          "end_arm", "loc_code","feat_type_code"}

    dw_data.of_setmultitable(true)
    dw_data.inv_multitable.of_AddToUpdate  &
        ("linear_feat", ls_linear_feat_keycols, ls_linear_feat_updcols, true, 0)
```

```
dw_data.inv_multitable.of_AddToUpdate  &
     ("ditch", ls_ditch_keycols, ls_ditch_updcols, true, 0)
```

dw_data.pfc_retrieve( ) Event

Similar to preceeding Bridge Pier Example.

```
Long  ll_rtn

ll_rtn = dw_data.Retrieve( is_sr_num , &
                                          is_rrt_code , &
                                          is_rrq, &
                                          is_incr_decr_ind, &
                                            id_begin_arm, &
                                            id_end_arm, &
                                            is_loc_code)

If ll_rtn > 0 Then
     cb_details.enabled = true
Else
     cb_details.enabled = false
End If

Return ll_rtn
```

Case 3 – Shoulder

W_Shoulder is inherited from W_LINEAR_FEATURE, even though the SHOUL table is not a dependent table to LINEAR_FEAT. W_LINEAR_FEATURE was chosen as an ancestor because the key columns for the SHOUL table are exactly the same as those for LINEAR_FEAT, with the exception of FEAT_TYPE_CODE. Since the ancestor code does not manage the FEAT_TYPE_CODE, the W_LINEAR_FEATURE window will suit the purposes well.

Since W_SHOULDER implementing a multiple table hierarchy like LINEAR_FEAT and DITCH in the preceeding example, no code is required in the dw_data.contstructor( ) event. Likewise, since there is no XYZ data associated with SHOUL, the cb_distance command button can be set not visible. This makes the W_DISTANCE window unavailable, and the ue_set_distance_keys( ) event will never be executed.

Case 4 – Barrier

W_BARRIER is inherited from W_LINEAR_WITH_CHILD, which , in turn, is inherited from W_LINEAR_FEATURE. The distinguishing feature for W_BARRIER is that it contains two datawindows, dw_data, and dw_detail. Dw_data and dw_detail are related through the PFC linkage service. Additionally, the dw_detail window is only used in the case of guardrail type barriers. It is not used for barriers of other types.

Thus, the code for the Open( ), pfc_new( ), ue_set_distance_keys( ) , dw_data.constructor( ), and dw_data.retrieve( ), is similar to prior examples. The pfc_preupdate( ) event is extended in order to copy key values from dw_data to dw_detail prior to a save and after successful editing. Additionally, the dw_data.itemchanged( ) event is coded to handle resetting of dw_detail based on the BARRIER_TYPE_CODE.

dw_data.Itemchanged( ) Event

```
int  li_rtn
Choose Case dwo.name
    Case "barrier_type_code"
        If data = "GR" Then
            dw_detail.inv_rowmanager.of_deleterow(1)
            dw_detail.event pfc_addrow()
            this.object.barrier_glare_screen_type_code[1] = 'N'
            dw_detail.of_setreqcolumn( true )
            dw_detail.setfocus()
        ElseIf data = "PC" OR data = "CP" Then
            dw_detail.inv_rowmanager.of_deleterow(1)
            this.object.barrier_glare_screen_type_code[1] = 'N'
        Else
            dw_data.setfocus()
            this.object.barrier_glare_screen_type_code[1] = 'N'
            dw_detail.inv_rowmanager.of_deleterow(1)
        End If
End Choose
```

The Control Run Window

Description

The control run window is a modal window. Its intend use is to capture bridge seat ARM values while the van is moving. Because of inherent delay times in transferring data on demand from the DMI to the computer, this window interfaces with the DMI in a different manner than the rest of the windows in the system. Additionally, it is inherited from the PFC w_sheet window, and thus does not use the application framework architecture.   However, it does use the U_DMI_RAC200 and U_DEFAULTS services.

Prior to capturing data, the DMI is placed in “Print 6” mode by clicking the “DMI Capture” button. In this mode, the computer waits for data to be transferred from the DMI. The DMI Enter button is used to transmit data immediately to the computer. The data is formatted as a report, as specified in the RAC 200 documentation. The W_CONTROLRUN window parses the data, and places the ARM value in the appropriate field.   The window operates on the assumption that if the cursor is on a begin arm field that is blank, incomming data will be placed in that field. If the field is non-blank, the END_ARM field on the same line will be populated with the incomming data. If the cursor is on an END_ARM field that is blank, the incomming data will be placed in that field. If it is non-blank, the data will be placed in the BEGIN_ARM field of the next line. If there is no next line, i.e. the cursor is on the last line, a new line will be added.

The window is designed to allow capture of control runs as either a Single Run, or a 3 Run Average. The choice of Single versus 3 Run Average is kept as a default in the Road.ini file, and is not an attribute of the run data. If data is being captured as a Single Run, average values are established on a save, based on the Run 1 values. If data is being captured as a 3 Run Average, average values are established upon capture of the last set of outstanding values, usually Run 3, and are averages of the Run 1, Run 2, and Run 3 values.

In order to maximize the flexibility offerer to the crew during control run data gathering, the window employs few edits. It only requires bridge names and unique bridge numbers when a record is identified as a bridge seat. It also allows the list of bridges to be built in advance, or on the fly as data is captured.

Once a given run is completed, the crew may decide to run the same State Route in the opposite direction. In this case, the user is prompted to either reverse the list of bridges, or to start with a blank control run screen.

Once capture of the data is complete, the data may be saved, and the session with the DMI is terminated. The data is then processed by the Office software.

Adding features to the Menus

New windows may be added to menus as would normally be done. Additions to existing menus are automatically reflected in the associated palette windows. If a new group of windows is required, then a new pallette window is required. First, new cascading menu items would need to be added to the m_file.m_open and m_file.m_new items on m_road representing the new 'group'. Under those 'group' items, add the menu items for the new windows. Once the cascading menus are completed, a new palette window can be created for the menu 'groups'. Inherit from W_PALETTE, and code the Open( ) event, as in the following example (from W_GEOMETRICS_PALETTE).

Setup the windows' source menus by establishing a pointer to the menu:

```
m_roadframe  lm_roadframe

lm_roadframe = gnv_app.of_getframe().menuid

im_new_menu  = lm_roadframe.m_file.m_new.m_newgeometrics
im_open_menu = lm_roadframe.m_file.m_open.m_opengeometrics
```

Once the references are made, W_PALLETTE.pfc_postopen( ) creates an instance of U_CB_PALETTE for each visible, enabled item under that menu, and establishes a pointer to that menu item. When clicked, each button will trigger the clicked event of its referenced menu item.

Batch Files

Currently the Road Van software uses a single batch file, roadvan.bat, to launch the program. Prior to launch, the batch file check for the existance of the road.cmp file, indicating a completion of the office processing, and a refreshed database and log copy are required. If the file is found, roadvan.db and roadvan.log are copied to the c:\road\ directory.

Upon termination of road.exe, the batch file then copies roadvan.db and roadvan.log to the shuttle drive's \road\ directory.

The Road Office Software

Description

The Road Office software is implemented on a single window, W_MERGE. This window is used to perform 6 major tasks:

1. Copy and consolidate changes to the Road Van database into the MS SQL Server database on the LAN. Currently, the SQL Server resides on the HOKI server. This task is accomplished by copying the roadvan.log file from the shuttle drive (removed from the van at the end of a data gathering period) to a backup drive, exporting the log to an ANSI SQL file, and processing the SQL transactions against the MS SQL Server database. The SQLAnywhere DBTRAN utility is used to export the log file. The command is of the form:

dbtran -r -s -y <targetdir > <officedir> \proclog.txt

where <targetdir> and <officedir> are specified in the Road.ini file as TargetDir and SourceDir respectively.

In the current implementation, the backup is done on the C: drive of the machine processing the data, under the directory specified as the TargetDir in the Road.ini file. Under this target directory, a datetime based subdirectory is created, into which the log file is copied.

2. Process Control Run data. This process involves inserting to or updating the STATE_ROUTE, LINEAR_FEAT, STRCTR, SR_BEGIN_PT, and SR_END_PT tables based on data in the RUN table. For records in the RUN table, if no STATE_ROUTE exists, insert a STATE_ROUTE. For RUN records identified as Bridge types, if no STRCTR record exists for the STRCTR_NUM, insert a LINEAR_FEAT and STRCTR record. If no SR_BEGIN_PT and SR_END_PT record exist for records identified as Begin or End types, insert records. If SR_BEGIN_PT and SR_END_PT records exist, update their BEGIN_ARM and END_ARM values.

3. Merge Pathfinder Files. Part of the process of data gathering in the field involves capture of XYZ data using GPS equipment. The equipment is capable of interfacing with Pathfinder Office, which allows correction of the data. Once corrected, the data is exported in a tab delimited format that may be imported into the Office software. Each entry in the exported file consists of an ITEM_ID_NUM (generated by the Road Van software on capture), and the Altitude, Latitude, and Longitude data. Once imported, the XYZ data is used to update corresponding feature data's XYZ information, based on the ITEM_ID_NUM on the record.

4. Display unprocessed ITEM_ID_NUMs found in the imported files, and log to the ISSUE table ITEM_ID_NUMs found in the database that have not been merged. Also, all items in the database which contain lookup table values indicating "unknown" types are also logged to the ISSUE table.
Increase the ITEM_ID_NUM of "unmerged" items in the database by 10,000. This allows recycling of ITEM_ID_NUMs, and limits the ITEM_ID_NUMs used in the field to 4 digits.

5. Refresh the Van Database. This task is accomplished by first copying a template SQL Anywhere database (called Roadvantemplate.db) to the target directory as Roadvan.db. This database contains the empty tables, with no referential integrity, and has logging disabled. The SQL Server database and the SQL Anywhere database are created using ROADVAN_CREATE.SQL, a DDL script generated in ERWin. This script contains only the DDL for the table creates. The SQL Server database also requires execution of ROAD_RI.SQL, which creates triggers which enforce referential integrity and cascaded deletes.

Once the copy is done, all data in the MS SQL Server database is copied to the Roadvan.db using dynamic datawindows. Once the data copy is complete, ROADVAN_FK.SQL is executed which enables referential integrity, including cascaded deletes. This script MUST contain a single ALTER TABLE statement adding a foreign key, with a declarative ON DELETE CASCADE clause. No blank lines are allowed in the file. After completion of this script, the SQL Anywhere DBLOG.exe utility is executed to enable database logging. When done, the Roadvan.db and Roadvan.log files are copied back to the original Shuttle drive directory, with a file called roadvan.cmp. Existence of this file on the shuttle drive signifies completion of the database refresh process.

Should it be necessary to add or drop tables from the database, it is essential that the SQL Server database and the SQL Anywhere databases be in sync. In order to assure this, the tables in SQL Server and the ROADVANTEMPLATE.DB databases must be the same, and contain the exact same column lists and datatypes. Furthermore, the scripts enforcing referential integrity must be modified to reflect the table changes. Any differences in these databases could cause execution or data errors.

6. Provide access to the ISSUE table. This is accomplished via the Exceptions tab on the merge window. This tab allows full access to the data in the ISSUE table.

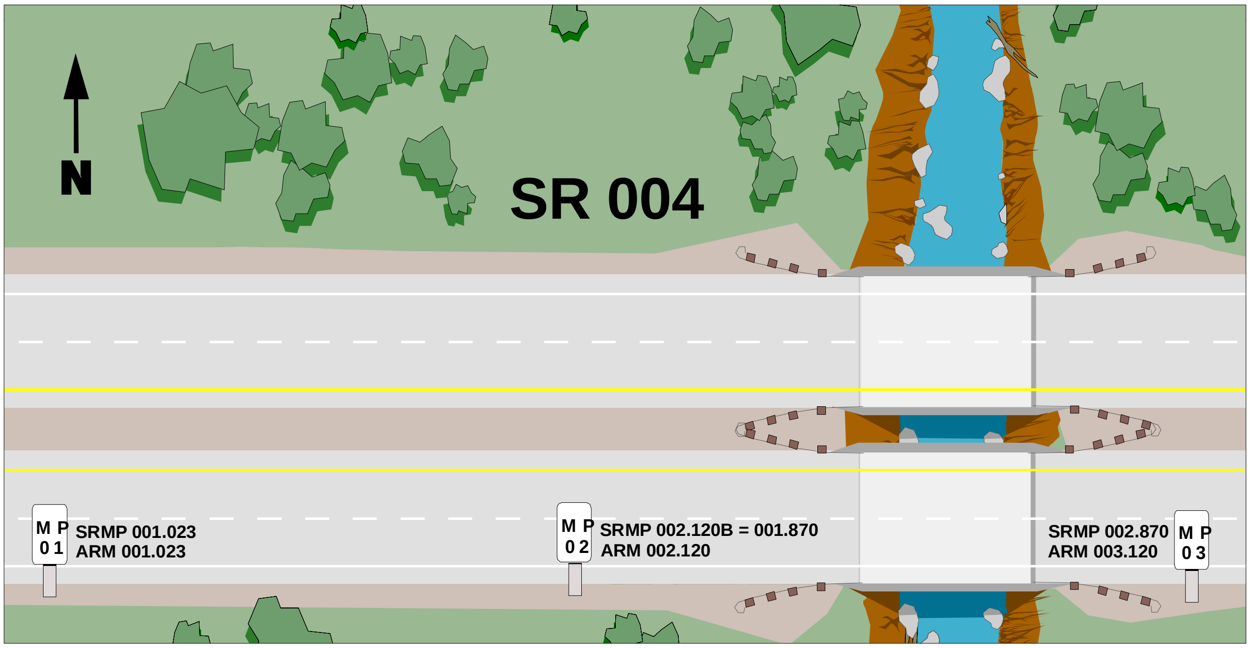
All of the major processing features are implemented as functions on the W_MERGE window and as SQL in the N_CST_ROAD SQL object. The functions are accessed via command buttons on the tabpages of the window. Generally, the window is used in a manual, step-by-step mode, where the user progresses from left to right on the tabs, running the functions they wish to run.

A progress window service U_PROGRESS is provided for visibility into long running processes.

The Merge window has the capability of running in an “unattended” mode. This mode is invoked by issuing a command to execute the RoadOffice executable (roadoffice.exe) with a command line argument of “/a”. In this mode, the process will run all of the major processing functions in sequence, stopping only if severe processing errors occur. This process assumes that 1) the source and target processing directories are correctly specified in the Road.ini file, and that all Pathfinder Office export files to be processed are in the source directory. This capability was not tested during the implementation of the system.

See the Road Object Reference for details on the W_MERGE window.

APPENDIX A
Linear referencing system



STATE ROUTE (SR)

A road for which the State of Washington has some level of responsibility that is identified by a three digit number (e.g., 004).

STATE ROUTE MILEPOST (SRMP)

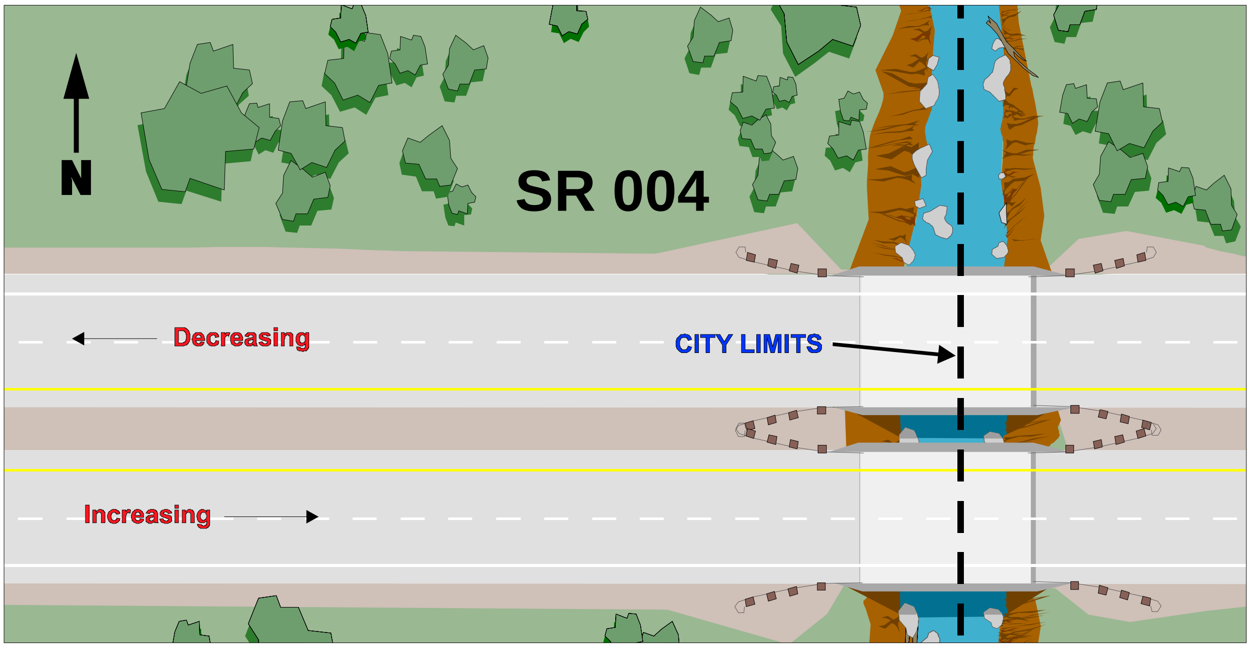
A linear referencing system used to assign a logical number to a given point along a route. Currently, the SRMP is carried to the hundredth of a mile (123.45). With the new ROAD Project, we will start carrying the SRMP to the thousandth (123.450). If a realignment shortens or lengthens a section of an SR, the SRMP will adjust with an equation and the SRMP will not change through the rest of the route.

The SRMP identifies reference points and should **NOT** be used for computing distance.

ACCUMULATED ROUTE MILE (ARM)

The ARM is an accrual of mileage from the beginning of a route to the end of the route. It accrues through coincident sections where two or more SR's share one physical alignment. The ARM is an important factor in the realignment of a State Route. It does **not** contain equations - it flows through them to give true mileage (see section on equations). Currently, the ARM is carried to the hundredth of a mile (123.45). With the new ROAD Project, we will start carrying the ARM to the thousandth (123.450).

All length measurements use the ARM value.



DIRECTION OF INVENTORY

Features that get tagged with this code occur **<u>ON</u>** the main traveled way.

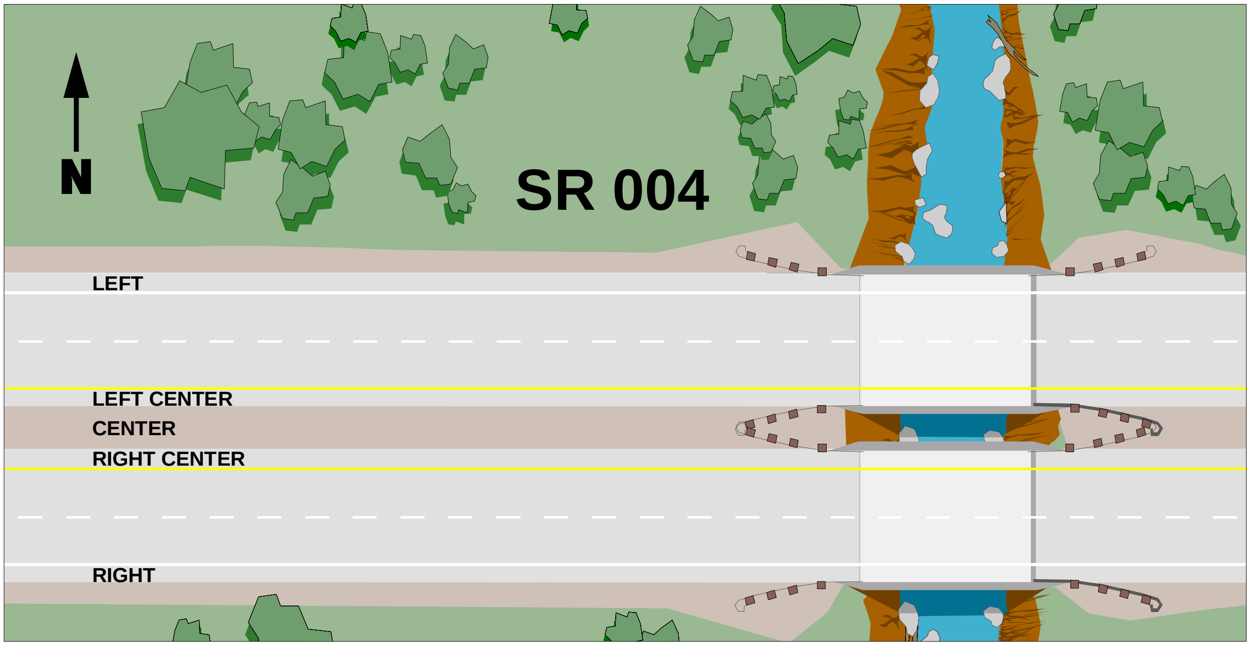
I = INCREASING (Inc) Milepost increases when traveling the roadway in the increasing direction. Usually odd numbered routes run south to north increasing and even numbered routes run west to east increasing. There are some exceptions to this rule.

D = DECREASING (Dec) Milepost decreases when traveling the roadway in the decreasing direction. Usually odd numbered routes run north to south decreasing and even numbered routes run east to west decreasing. There are some exceptions to this rule.

B = BOTH The feature affects both the increasing and decreasing direction of travel. Examples:

- Bridge (overcrossing)
- Street Name
- Number of Lanes

- Speed Limit
- Legislative District
- Horizontal Alignment



LEFT/RIGHT INDICATOR

Features that get tagged with this code occur **ALONG SIDE** the main traveled way. All Left Right Indicators are assigned based on the **INCREASING** direction of travel, starting from the left and working to the right.

L = LEFT Represents features located along side the decreasing traveled way.

LC = LEFT CENTER Represents features located along side the median side of the decreasing traveled way.

C = CENTER Represents a feature that occurs between the increasing and decreasing traveled way.

RC = RIGHT CENTER Represents features located along side the median side of the increasing traveled way.

R = RIGHT Represents features located along side the increasing traveled way.

B = BOTH The feature occurs along side both the increasing and decreasing traveled way. Examples:

- Parking Zone
- Park n Ride Lot
- Weigh Station

- Flyer Stop
- Rest Area
- Intersection

STATE ROUTE MILEPOST BACK (B) INDICATOR

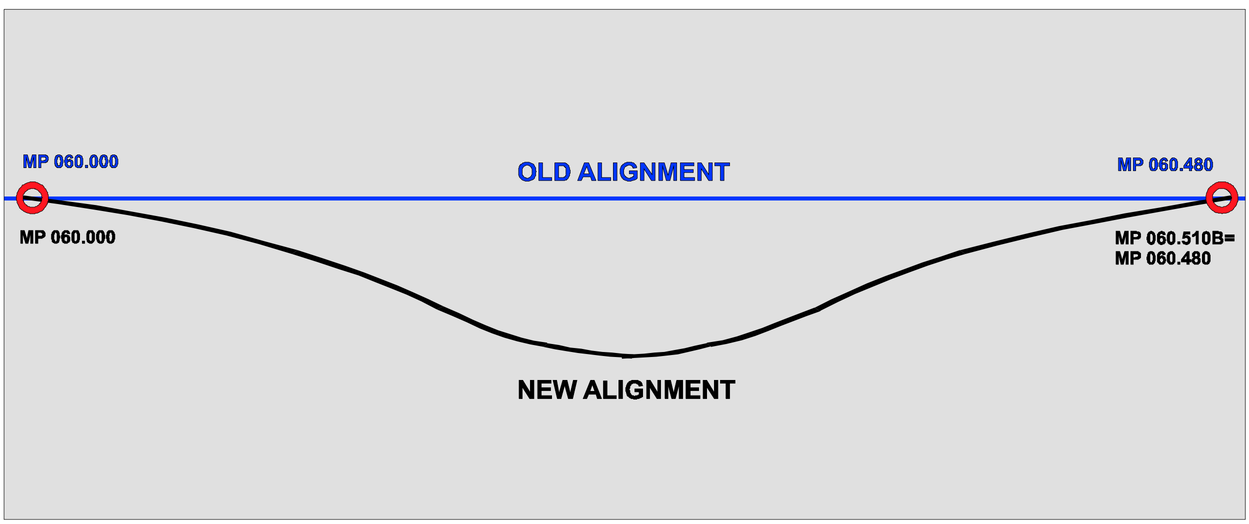
Indicates whether the milepost value is the duplicate (back) of a milepost value on the route. Ahead values are implied (blank).

A back SRMP occurs as a result of:

- Realignment which lengthens a section of an SR other than at the end of the route.
- Adding mileage to the beginning of an SR.

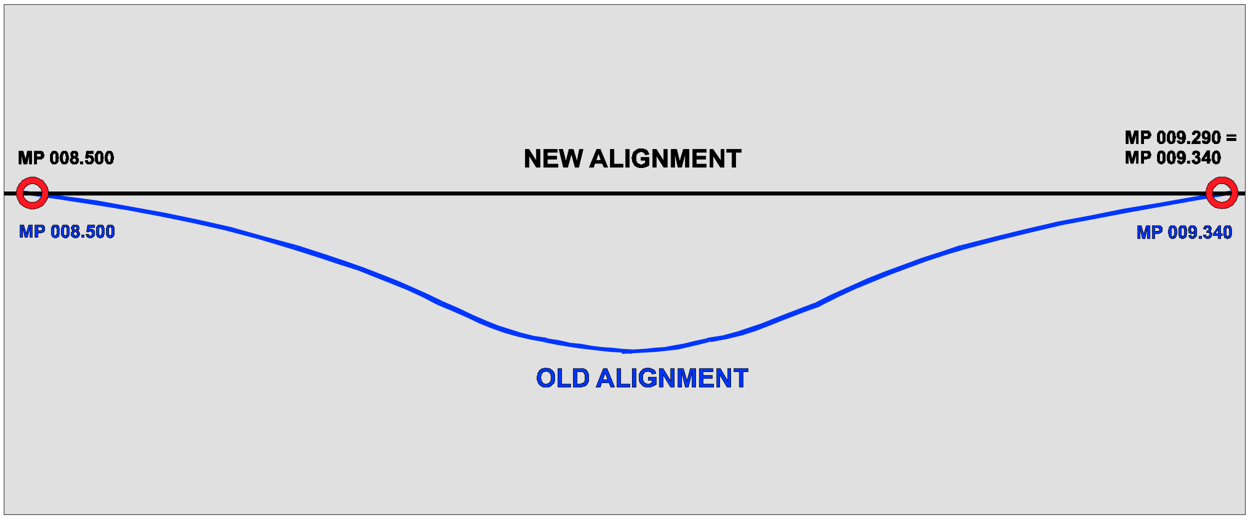
EQUATION (EQ)

There are 3 kinds of Equations: Back, Gap & Physical Gap



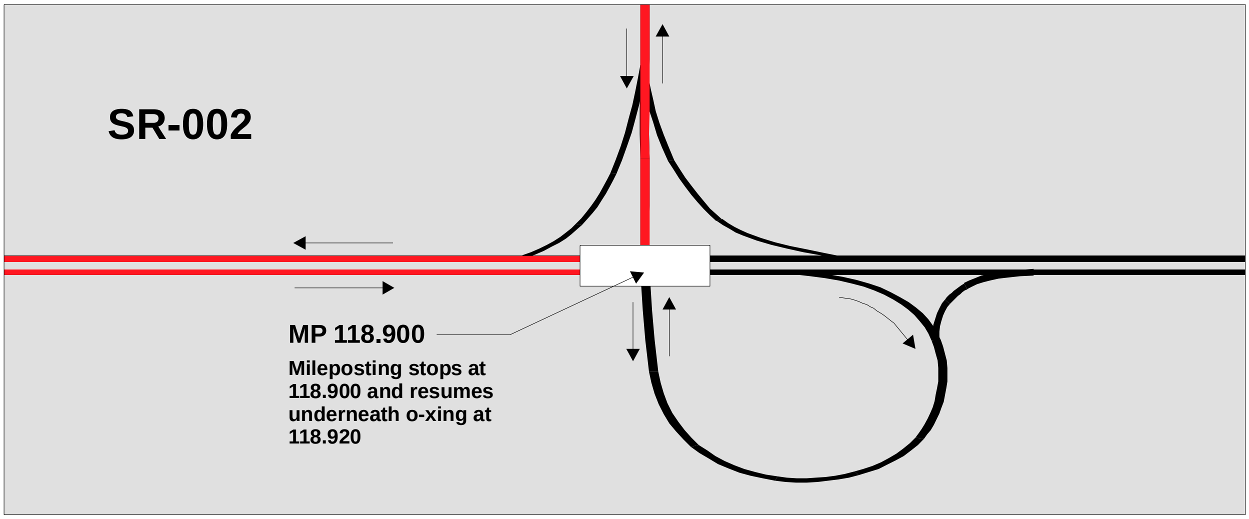
BACK EQUATION

This type of EQ occurs when a realignment lengthens a section of an SR. An example (shown above) would be a contract that reconstructs the alignment of a SR from MP 060.000 to 060.480. As a result, the alignment is .030 longer. Because 060.480 to 060.510 already exists (not part of the alignment change), the MPs that are duplicated need to be identified. This is done by assigning a 'B' (back) to the new MPs 60.480, 60.490. 60.500, and 60.510. This lengthening will result in a Back EQ of 60.510B = 60.480. The MP of 60.510B is no longer a valid MP as two MPs cannot occupy the same point. This allows for adjustment to the section affected but does not affect the MP of the rest of the SR. The ARM is the factor that gets adjusted for the rest of the SR.



GAP EQUATION

This type of EQ occurs when a realignment shortens a section of SR. An example might be a contract that reconstructs the alignment of a SR from MP 8.500 to 9.340. Throughout this section some curves are straightened out and the alignment is .050 shorter (8.500 - 9.290). This shortening would result in a gap EQ of 9.290 = 9.340 at MP 9.340. The MP of 9.290 is no longer a valid MP as two MPs cannot occupy the same point. This allows for adjustment to the section affected but does not affect the MP of the rest of the SR. The ARM is the factor that gets adjusted for the rest of the SR.



PHYSICAL GAP

This indicator may or may not have an EQ associated with it. A Physical Gap is a location where there is a physical break in the continuity of the SR. An example would be SR 2 in Wenatchee where SR 2 MPs stop at the end of the overcrossing (MP 118.900) then resumes at the center of the undercrossing (MP 118.920).

COINCIDENT (COINC)

This situation occurs when two (or more) SRs run along the same physical alignment. A Coinc location carries one Major SR and 1 to 3 Minor SR(s). The Major SR carries all the data. The Minor SR(s) will only contain Region and County numbers.

The assignment of Major or Minor is first based on functional classification. A Principal Arterial would take precedence over a Minor Arterial and/or Collector. A Minor Arterial would take precedence over a Collector. A Interstate would take precedence over all other routes. If both highways have the same functional classification, the route with the lowest SR number will take precedence. ARM accumulates through the Coinc section on the Minor SR. A listing is available that identifies Coinc locations by SR, SRMP & ARM.

RELATED ROADWAY TYPE (RRT)

Before TRIPS, the SR number represented the main traveled way of our highways. This left out other pieces of our highways like Ramps, Spurs, Couplets, etc. and in numerous cases, caused location data to be inaccurate.

With TRIPS came RRT and RRQ. Together with the SR number, these descriptors identify very precisely any piece of the highway system in the State.

RRT = A two character abbreviation for a type of roadway. The following is a list of RRTs in the system.

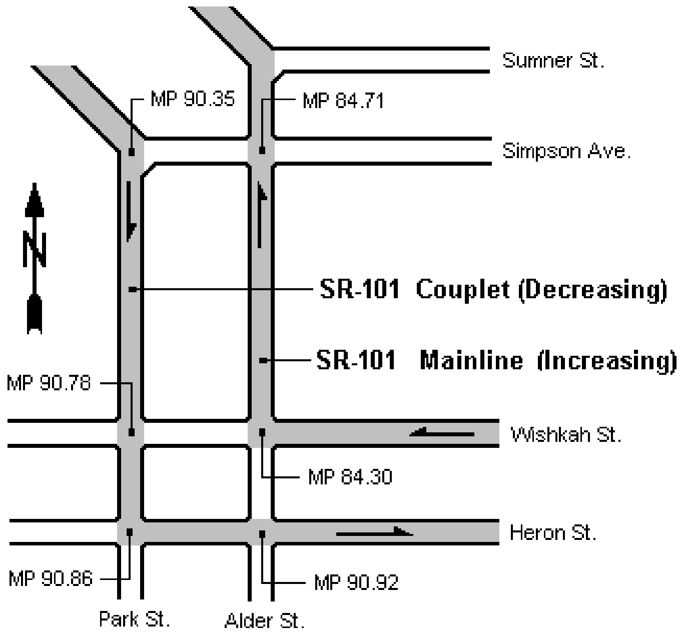
AR	Alternate Route	CD	Collector Distributor Dec
CO	Couplet	CI	Collector Distributor Inc
FD	Frontage Road Dec	LX	Crossroad within Interchange
FI	Frontage Road Inc	P1 - P9	Off Ramp, Inc
FS	Ferry Ship (Boat)	PU	Extension of P ramp to PI
FT	Ferry Terminal	Q1 - Q9	On Ramp, Inc
PR	Proposed Route	QU	Extension of Q ramp to PI
RL	Reversible Lane	R1 - R9	Off Ramp, Dec
SP	Spur	RU	Extension of R ramp to PI
TB	Transitional Turnback	S1 - S9	On Ramp, Dec
TR	Temporary Route	SU	Extension of S ramp to PI
YC	Wye Connection		

RELATED ROADWAY QUALIFIER (RRQ)

The RRQ is a six digit field which uniquely identifies the RRT since there may be more than one of of the same type of RRT for a route. The assigning of RRQ is done in one of three ways depending on the RRT.

(1) The following RRTs use descriptive location names (i.e., city, street, or junction) for the RRQ and the begin SRMP of that RRT is relative to the Mainline SRMP where the RRT intersects with the Mainline.

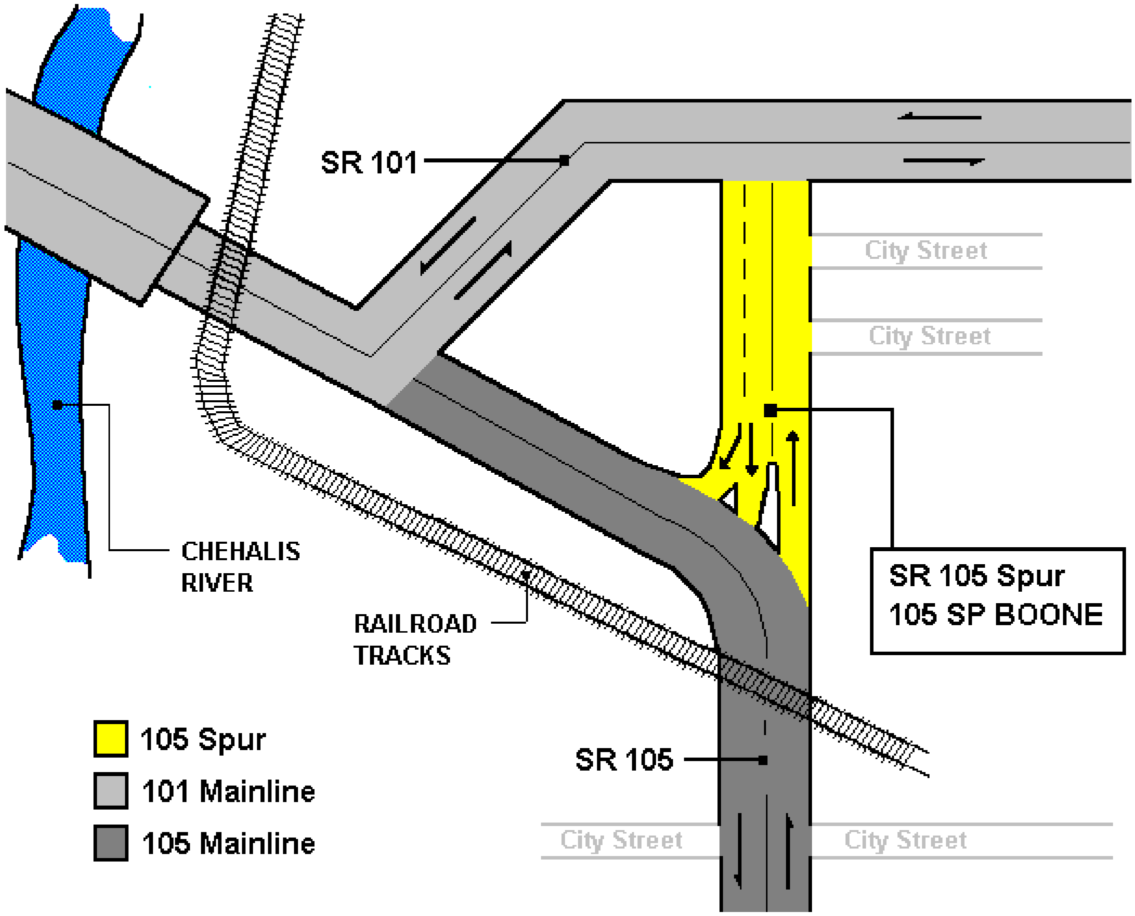
AR	Alternate Route	SP	Spur
CO	Couplet	TB	Transitional Turnback
PR	Proposed Route	TR	Temporary Route



Grays Harbor County
Aberdeen
SR-101
SR-101 CO ABERDN

EXAMPLE: 101 CO ABERDN

where:	101	=	SR Number
	CO	=	RRT for Couplet
	ABERDN	=	Abreviated name of city where RRT exists



(2) The following RRTs use the Mainline SRMP where the RRT attaches to the Mainline. The begin SRMP for that RRT will be 0.000.

CD	Collector Distributor Dec	P1 - P9	Off Ramp, Inc
CI	Collector Distributor Inc	PU	Extension of P ramp to PI
FD	Frontage Road Dec	Q1 - Q9	On Ramp, Inc
FI	Frontage Road Inc	QU	Extension of Q ramp to PI
LX	Crossroad within Interchange	R1 - R9	Off Ramp, Dec
RL	Reversible Lane **	RU	Extension of R ramp to PI
YC	Wye Connection	S1 - S9	On Ramp, Dec
		SU	Extension of S ramp to PI

*** At this time, this RRT does not follow standard naming convention*

EXAMPLE: 005 R1 12772

where:	005	=	SR Number
	R1	=	RRT for Off Ramp Dec
	12772	=	Mainline SRMP where R1 taper begins

(3) The following RRTs use descriptive names such as a city or ship name for the RRQ. The begin SRMP is always a zero value (000.000).

FS Ferry Ship
FT Ferry Terminal

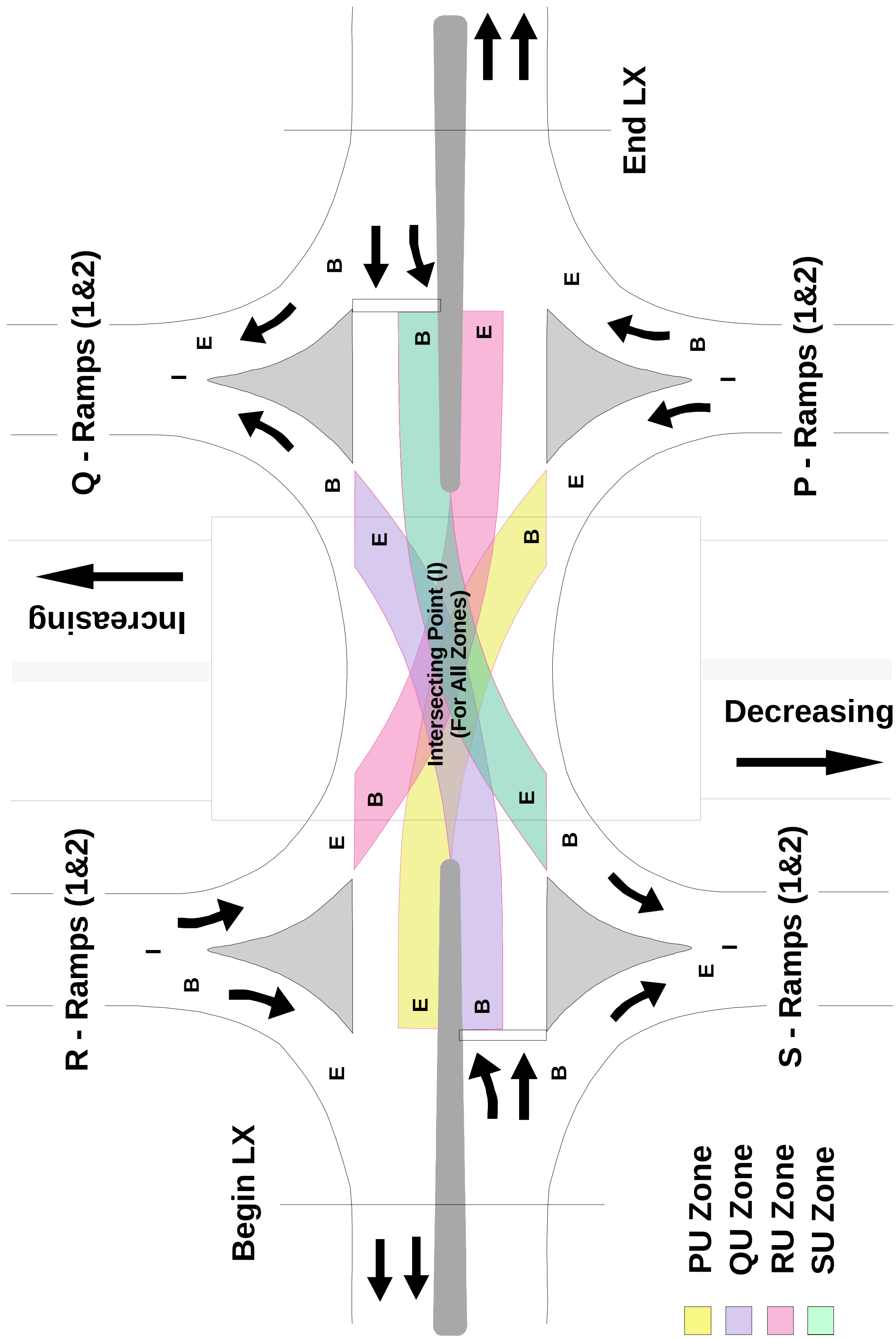
An SR number of 999 is used for Ferry Ships since they are not assigned to a specific route. The RRQ represents the name or abbreviated name of the ship.

An SR number of 999 is used for Ferry Terminals only if the terminal is not located on a route. The RRQ represents the name or abbreviated name of the city where the terminal is located.

REALIGNMENT

A mechanism by which the SRMP, ARM, Date, and Mileage adjustments of a given State Route are tracked.

TYPICAL SINGLE POINT (URBAN) INTERCHANGE CONFIGURATION



APPENDIX B
Global Positioning System

GPS Background

The Global Positioning is a US military satellite system that provides continuous, accurate and instantaneous positioning anywhere on or above the earth. GPS is best described by understanding the 3 major segments that form the full system:

- The space segment
- The control segment
- The user segment.

The space segment is made up of 24 satellites (21 plus 3 active spares) that orbit the earth with a period of about 12 hours. The satellites (or space vehicles - SVs) are arranged to optimize coverage so that at least 4 satellites are visible at all times from anywhere on earth. Each satellite contains atomic frequency standards (clocks) that are extremely precise allowing them to remain synchronized with other GPS satellites and also with the ground control system. All satellites broadcast at the same frequencies, but each has a unique PRN (Pseudo Random Noise) code which identifies a particular satellite and allows a ground-based receiver to make time-based distance measurements to each satellite. Each satellite also broadcasts the data elements necessary to compute the position of that satellite within its orbit (with respect to the global datum) at a particular time. These data elements are called the ephemeris message.

The control segment consists of monitoring stations at various locations around the earth, plus a master control station in Colorado Springs. The control stations monitor satellite performance, determine their orbits, model the atomic clock behavior, and inject (upload) each satellite with their broadcast data (the ephemeris message).

The user segment includes any user equipped with a GPS receiver. In the basic mode of GPS operation (pseudoranging), the user's receiver aligns a replica of each PRN code with the incoming signal from the satellites and thus determines a distance (range) to each satellite. However, because the user's receiver is not precisely synchronized with the GPS system, this time-based one-way range is corrupted by an unknown amount referred to as the "range bias" or "user clock offset" (this is why the mode of positioning is called pseudoranging rather than ranging). The magnitude of the resulting error is approximately the clock error times the speed of light. With four pseudorange measurements combined with the satellite positions from the ephemeris messages, the range bias can be computed along with the 3 dimensional coordinates for the user's receiver. In most cases it is the position that is important to the user and the range bias is ignored. If more than 4 satellites are visible, the user's position can be improved by using all measured pseudoranges in an over-determined solution.

GPS History

GPS developed from earlier satellite navigation systems of the 1960s and 1970s. The first GPS satellites were launched in 1978 and gave limited coverage during the initial development years that followed. Commercial receivers became available in the early 1980s and the civilian use of GPS began modestly, gathered momentum as new measurement techniques were invented and refined, and has now exploded to the level where civilian users far outnumber military users. The space shuttle Challenger disaster of 1986 set-back the GPS launch program, and it was not until 1993 that the system was declared IOC (Initial Operational Capability). The system was declared FOC (Full Operational Capability) as of December 12, 1995.

GPS Positioning Techniques

The mode of positioning described above (pseudoranging) is available at two accuracy levels. Military users have access to the PPS (Precise Positioning Service) via tracking of the P (or Y) codes which can produce instantaneous autonomous horizontal accuracies of better than 10m using a single receiver. Civilian users have access to the SPS (Standard Positioning Service) via tracking of the C/A (Coarse Acquisition) code. The SPS is deliberately corrupted to limit the horizontal accuracies to 100m (95% of the time). The process of corruption is called Selective Availability (SA) and includes "dithering" of each satellite's atomic clock and/or the broadcast ephemeris. Note that SPS accuracies affect all commercial receivers (i.e. the cheapest to the most expensive. It should be noted that vertical accuracies are typically 1.5 - 2 times worse than the horizontal accuracies.

The SPS horizontal accuracy level of 100 meters is suitable for general navigation and recreational use, but falls short of the accuracies needed for most surveying and navigation tasks. It did not take long for users to find ways to improve the accuracies available from GPS.

Code, or pseudorange, Differential GPS (commonly known as DGPS) is a technique based on a receiver operating at a previously surveyed location to allow calculation of the SA corruption, and then make these differential corrections available to other GPS users working within the local area. DGPS can produce accuracies in the range of 0.3 to 10 meters depending on a number of factors. For example:

- GPS satellite configuration (geometry)
- GPS data collection environment (i.e. blockages, multipath, etc.)
- GPS field receiver type
- GPS Reference Station receiver type
- GPS post-mission processing software
- GPS Reference Station and field receiver separation distance

Many DGPS surveys are processed post-mission by merging the raw GPS data recorded at both the Reference Station (or base station) receiver and at the field (or rover) receivers. DGPS can also be applied in real-time with a communication link between the reference station and rover (i.e. radio, satellite, cellular phone, etc.). To remove the short-term effects of SA, the real-time differential corrections must be received at the field GPS unit within 10 seconds of the time when they are calculated at the reference station. This delay time is called the "latency" of a real-time system.

The original differential methodology developed in the early 1980s was based on a simple positional correction calculated at the reference station (corrections to latitude, longitude and height) which were then applied to the rover unit's solved position. This methodology is also known as "spatial" DGPS, or "position-based" DGPS (ground domain).

By the mid 1980s a more rigorous DGPS technique was developed by calculating the individual corrections to each pseudorange and applying them to the rover's measured pseudoranges before solving for the position. This methodology is also known as "measurement-space" DGPS, or "space-based" DGPS (space domain). This increased the possible accuracy and also relaxed the operating restrictions as it was no longer required for the reference station and the rover receivers to track the identical set of satellites. Surprisingly enough, some manufacturers are still using a form of spatial DGPS in their current software.

In the never-ending quest for improved accuracies, some early researchers recognized the possibility of using the GPS signal in a similar manner to VLBI (Very Long Baseline Interferometry). In this technique, the GPS phase angle of the carrier wave(s) are tracked and recorded at a number of receiver sites, and are then processed together post-mission using software to form interferometric differences. This results in precise relative "baselines", or vectors (3 dimensional coordinate differences) between each receiver pair. The amount of GPS data needed for a strong solution is dependent on factors that include satellite geometry and the length of baseline, with time periods of 40 - 120 minutes of static observations being typical. The precision of these measurements range from a few millimetres to a few decimetres, and is usually expressed as a PPM (Part Per Million) of the baseline length. To obtain the most precise results, the integer number of carrier wavelengths between each receiver and satellite pair must be resolvable. This process is called ambiguity resolution.

Static phase techniques soon developed into kinematic phase solutions with centimetre-level accuracies possible within less than a minute of observation. Kinematic solutions require the receiver to maintain phase lock on at least 4 satellites at all times, however, observations from 5 satellites are required to detect and correct cycle slips. These solutions are best suited for project areas that are substantially free of obstructions. GPS receivers that can track and record the carrier phase are generally classified as geodetic instruments.

Dual frequency receivers can take advantage of the "wide lane" technique (a numerical combination of phase measurements on the two frequencies) to make precise static baseline measurements in 5-15 minutes within a localized area. This technique is called Rapid Static or Fast Static. Dual frequency receivers also have an accuracy advantage for long baseline measurements (>25km) as the ionospheric signal delays can be directly measured and applied. This is not possible with single-frequency receivers. Both single and dual frequency baseline measurements can be adversely affected by wildly fluctuating ionospheric conditions during geomagnetic storms. These storms are somewhat predictable and various prediction services are distributed via the BCACS Bulletin Board Service (BBS) and Web-site. Recent advances have made it possible to have centimeter-level accuracies in real time using phase measurement techniques. Terminology associated with these new techniques are RTK (Real Time Kinematic) and OTF (On The Fly ambiguity resolution).

APPENDIX C
List of Acronyms

ARM	Accumulated Route Mile
B	State Route Back Milepost Indicator
CAD	Computer Aided Design
CEP	Circular Error Probable
COINC	Coincident
D or DEC	Decreasing Inventory Direction
DGPS	Differential Global Positioning System
DOP	Dilution of Precision
EQ	Equation
EDOP	East Dilution of Precision
GCM	Geodetic Control Monument
GDOP	Geometric Dilution of Precision (3D plus Time)
GIS	Geographic Information System
GPS	Global Positioning System
GSR	Geo-Spatial Reference
HDOP	Horizontal Dilution of Precision (2D)
I or INC	Increasing Inventory Direction
LADGPS	Local Area Differential Global Positioning System
LDGPS	Local Differential Global Positioning System
NAD27	North American Datum 1927

NAD83	North American Datum 1983
NAVD88	North American Vertical Datum 1988
NDOP	Northing Dilution of Precision
PDOP	Position Dilution of Precision (3D)
PI	Point of Intersection
RINEX	Receiver Independent Exchange format
RRQ	Related Roadway Qualifier
RRT	Related Roadway Type
Rx	Receiver (i.e. GPS Rx)
SNR	Signal to Noise Ratio
SR	State Route
SRMP	State Route Milepost
TDO	Transportation Data Office
TDOP	Time Dilution of Precision
VDOP	Vertical Dilution of Precision (1D)
WADGPS	Wide-Area Differential GPS
WGS84	World Geodetic System 1984